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REPORT OF THE NOAA-SEAMAP DEEPWATER HORIZON WORKSHOP: SCIENCE NEEDS AND APPROACHES FOR IMPROVED STOCK ASSESSMENT, ECOSYSTEM MANAGEMENT, AND MARINE SPATIAL PLANNING

U.S. DEPARTMENT OF COMMERCE
National Oceanic and Atmospheric Administration
National Marine Fisheries Service
Southeast Fisheries Science Center
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NOTICE

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Executive Summary

This document describes the results of two workshops sponsored by NMFS Southeast Fisheries Science Center, NMFS Office of Science and Technology and the Gulf States Marine Fisheries Commission. These workshops, held in response to the Deepwater Horizon Incident, were intended to evaluate the status of fishery-independent surveys in the Gulf of Mexico. A small planning workshop was held in Miami on the 25 to 27 of August, 2010. The second workshop, held on the 23 and 24 of September 2010 in St. Petersburg, Florida, was a larger gathering of academics, state representatives, non-governmental organizations, U.S. and Mexican federal scientists, and private industry representatives. These workshops were not intended to develop a consensus view, but were instead based on the model of a 'think tank' to collect ideas for further consideration.

The meeting used four small working groups as vehicles to generate ideas for improving regional capabilities in the following four areas: 1) Survey design and statistics; 2) Application of advanced technologies to improve surveys; 3) Leveraging and building effective partnerships for data collection and sharing; and 4) Ecosystem assessment and marine spatial planning. These areas were viewed as central to the missions of the SEFSC and NOAA-Fisheries in general and would likely be among the core focal areas needed to improve fishery independent survey capability in the Gulf of Mexico.

Resource surveys are one of the underpinnings of stock assessments, natural resource damage assessments, assessments of climate change, assessment of invasive species, and could be critical components for assessing seafood safety and contaminant exposure across marine and coastal ecosystems in the Gulf. These surveys are also core components of Integrated Ecosystem Assessments and Coastal and Marine Spatial Planning programs. One critical point to be communicated is the central role resource surveys play in addressing multiple missions related to maintaining healthy, sustainable ecosystems and public well-being.

While events such as the Deepwater Horizon Incident underscore the value of high quality background information that is currently drawn primarily from routine surveys, increasingly tight budgets constrain the operating scope of these surveys. To continue to provide high-quality routine monitoring for stock assessments as well as to ensure seafood safety and to monitor ecosystem health we will have to find ways to increase the efficiency of resource surveys This may be accomplished by improved survey designs, employing advanced sampling technologies, and/or the integration of capacities across agencies to meet multiple goals.

Conceptually, the four working groups employed in this workshop reflect a plan to systematically improve fishery independent sampling, stock assessments, and move the Gulf of Mexico region toward ecosystem-based management, but this framework is perhaps universally applicable. The Gulf of Mexico is unique with its extensive at-sea fossil fuel extraction infrastructure and severe weather risk, but all regions face both anthropogenic and natural threats and could benefit from lessons learned here.

The four working groups were seen as synergistic efforts to evaluate traditional survey and monitoring efforts and provide recommendations for improvements. First, there was a need to review the statistical bases of existing surveys, improve designs, and develop advanced analytical approaches. Second, existing sampling methods could be augmented by emerging technologies to improve the quality and scope of data returned from surveys. Many of these technologies did not exist when current surveys were established; nor did our conceptual models of the importance of habitat and the role of environmental forcing. There is a pressing need to update survey technology in the Gulf of Mexico and elsewhere. But, because mathematics and engineering advance continually, updating survey technology should become a continual, supported process of improvement – not just a one-time, inflexible event. Third, the Deepwater Horizon Incident demonstrated the absolute need for streamlined data collection and sharing, partnerships, and effective resource allocation. Difficult to access data is not useful data and generating usable 'ecosystem intelligence' requires coordination and planning. Fourth, because fisheries management would be better served by considering the ecosystem in population dynamics, an integrated approach to understanding the dynamics of the system is needed. Advancing in these four areas would move us toward effective ecosystem-based management and marine spatial planning.

Overall, the workshop yielded a number of very interesting ideas. Among the most prominent were *developing a broad-based academic-government working group to enhance survey design and analytical capabilities within NOAA-Fisheries and its partners*; *investigating a suite of promising modern technologies to improve survey methodology and address critical data gaps*; *developing better partnerships with stakeholders while addressing concerns over jurisdiction and intellectual property*; and *developing a working group to accelerate the process of understanding the dynamics of the Gulf of Mexico Ecosystem* and helping to build an Integrated Ecosystem Assessment and Coastal and Marine Spatial Planning program for the Gulf. Summary findings for each of the four working groups follow.

Survey Design and Statistics Summary Points

- **Assessment of existing surveys**
    - No straightforward, simple solutions exist for the challenges facing fishery independent survey programs in the Gulf of Mexico.
    - Changing the basic survey designs during the course of the investigation into the spill is unwise, but carefully considered augmentation is encouraged.
    - Efforts to identify changes arising from episodic events (i.e., red tides, Deepwater Horizon) may be better focused on abundant species (i.e., Atlantic croaker) first to take advantage of potentially higher signal to noise ratios.
    - Stratification can be done post-survey, if needed, provided adequate information is available to base the stratification upon (covariates would be exceptionally helpful).
    - Proposals to increase sample size are expensive, brute-force approaches that reduce variability for some species, but not all.
- **Improvements in survey design, data analysis, and modeling are warranted**
    - Existing data may be up to the challenges posed by Deepwater Horizon, but analysis would benefit from application of computationally-intensive statistical approaches (i.e.,

Markov-Chain Monte-Carlo methods). This process would benefit from greater NOAA-Fisheries collaboration with the academic community and other federal agencies.

  - Survey design and analysis may benefit from more efficient methods (i.e., matrix sampling, split-questionnaire, data fusion, rotating panel, dose-response methods, asymmetric eigenvector mapping).
  - Establish a focused working group of academic, federal, and state scientists to develop statistical simulations, advance analytical methodology, and refine survey techniques is supported.
    - This group could focus on regional issues or function at a higher level to improve survey efforts nationally and could serve as a primary vehicle for improving NOAA capabilities in this area.
  - Substantial potential exists to improve fisheries independent surveys through improvements in design, analysis, and field efforts while achieving greater efficiency and cost-effectiveness.

Survey Development Research and Advanced Technology Summary Points

- Fisheries independent surveys are a critical source of information for stock assessments, natural resources damage assessments, and gauging the impacts of contaminants, episodic events, climate change, and resource extraction on ecosystem dynamics.
- Surveys, while meeting mission critical needs, should become multi-purpose and designed to *assess ecosystem health and dynamics and collect information relevant to addressing tomorrow's challenges*.
- Greater use of quantitative collection methods, such as net/gear mensuration, is needed to provide high-order data streams for management and assessment.
- Methods to reduce analytical complexity in multi-purpose surveys would be advantageous.
- *Collection and classification of habitat metrics (both benthic mapping and water column structure and dynamics) is a critical need for refining survey interpretation and design.*
- Assessment and management should make greater use of environmental data to increase the value of survey data.
- Many technologies (i.e., imaging technology, AUVs, molecular biological methods, advanced sonars, modern statistics, satellite observations, IOOS support) exist or are in development and could streamline survey tasks and greatly aid the conduct and interpretation of surveys.
- There are significant advances in biological sensors (i.e., molecular tools, DNA barcoding, tagging, isotope methodology) that should be prepared for adoption into the NMFS-wide toolbox of technologies.
- *Developing capacity (i.e., people, training, equipment, infrastructure, and funding) is critical to the success of improving fisheries surveys .*

Data Collection, Sharing, and Partnerships

- Effective response, damage assessment, and mitigation require working across the boundaries between *all* stakeholders. Mechanisms to work across boundaries must be in place *before* they are needed.
- Enhanced collaboration and formal support will lead to more cost-effective monitoring and better science for resource managers.
- A large and growing number of potential partners exist in the Gulf of Mexico. Organization and streamlining for these groups are very important and could be very challenging.
- Challenges to effective partnerships and data sharing exist with respect to:
    - Varying data formats, quality control and assurance procedures
    - Complex data access mechanisms (e.g., no single portal, need to contact individuals holding data)
    - Confidentiality and intellectual property issues (if data is to be shared, mechanisms to protect these interests must be developed).
    - Lack of data inventory, and storage on outdated media
    - Data 'ownership' issues[1] (ranging from individual to governmental to private industry interests and areas of operation).
- There are several data and capability gaps that should be addressed through greater partnerships, including
    - A shortage of trained taxonomists (genetic techniques may help alleviate this need)
    - Complex and data-poor fisheries
    - Unprocessed SEAMAP plankton samples and data
    - Lack of observational data on non-target species
    - Lack of data on covariates
- Mechanisms to create and expand partnerships include:
    - Supply dedicated, long-term, consistent funding
    - Identify and **support individuals** to maintain the progress and **enthusiasm** for the program.
    - Identify clearly the benefits of greater cooperation between agencies along with prescribed protections for intellectual property
    - Improve cross-disciplinary investigations and analyses
- Develop a public relations program to facilitate greater partnerships through active engagement with stakeholders.

Ecosystem Management and Marine Spatial Planning Summary Points

- The Gulf possesses significant industrial infrastructure both at sea and along the coastline. It also has incredible habitat and species diversity, as well as high risks for extreme weather events.

[1] The 2013 White House Office of Science and Technology Policy Memorandum Increasing Access to the Results of Federally Funded Scientific Research (OSTP PARR Memo) should alleviate some issues.

- The Gulf is an enclosed ocean basin in an area that is forced, in part, by interplay between El Nino and Atlantic Warm Pool dynamics and is vulnerable to climate-scale variability – northerly range expansion is not possible for many Gulf organisms.
- Developing a framework for ecosystem management and coastal and marine spatial planning will help facilitate the development of a well-managed Gulf of Mexico ecosystem. Such a system would:
    - Support desirable ecosystems, be free of anthropogenic contaminants, and will not foster the development of undesirable conditions (i.e., contaminated areas, red tides, dead zones, reduced natural production, reproductive dysfunction, anomalous behaviors, loss of biodiversity, increased disease prevalence).
    - Possess adequate monitoring to rapidly identify anomalies, have in place decision making processes that allow for rapid assessment of any negative signals in the monitoring data as well as mitigation of the sources of those signals
    - Support multiple, sometimes conflicting, uses with well thought out and equitable planning and enforcement mechanisms in place.
    - Use partnerships between resource user groups and managers to plan development, mitigate conflicts, and monitor the health and dynamics of the system.
- Recommendations to achieve these goals include:
    - Identify professional staff to organize and shepherd the program
    - Ensure support and commitment to the program by a core group of federal, state, non-governmental organizations, public, and industry partners.
    - Set funds aside to support a Working Group that will operate 'by-correspondence' and which has the goal of laying the groundwork for developing these programs through a 'SEDAR'-like iterative, peer review process to prioritize the analyses of databases, facilitate integration, and begin understanding the historical dynamics of the Gulf of Mexico ecosystem.

Workshop Participants

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Introduction, Context, and Background

The oil spill following the explosion and sinking of the Deepwater Horizon semi-submersible drilling rig on 20 April of 2010, presented substantial challenges to the legislatively mandated work of the Southeast Fisheries Science Center (SEFSC). The SEFSC is the NOAA-Fisheries science agency charged with managing the living marine resources of the Gulf of Mexico. Oil and dispersants released into the Gulf and the fishery closures themselves created new sources of uncertainty for stock assessments, highlighted the lacunae in our knowledge of food web linkages, and generated significant questions regarding everything from event-appropriate fisheries survey methods to possible spill-related changes in life history vital rates. Because of potential wide ranging effects, the Deepwater Horizon Incident is a case study in issues that ecosystem management and coastal and marine spatial management -- two NOAA initiative areas - are intended to address.

During the preparation of this memorandum, a difficult and costly investigation into the impacts of the Incident was ongoing. This effort deployed cutting edge science and struggling with many issues that will need to be addressed for effective coastal ocean management. The lessons learned from the investigation will reveal opportunities to dramatically improve the nation's approach to managing the resources of the coastal ocean. As an agency, we should make maximum use of those opportunities.

There were many responses to the Deepwater Horizon Incident, including a variety of workshops held by various institutions in attempts to organize efforts to deal with the spill. The NMFS Southeast Fisheries Science Center and NMFS Office of Science and Technology, along with the Gulf States Marine Fisheries Commission held two such workshops. The first was a small planning workshop in Miami on the 25 to 27 of August, 2010 (see Appendix A for report and supporting materials). The second workshop, held on the 23 and 24 of September 2010 in St. Petersburg, Florida, was a much larger gathering of academics, state representatives, non-government organizations, U.S. and Mexican federal scientists, and private industry representatives. This workshop was never intended to develop a consensus view, but was instead based on the model of a 'think tank' to collect ideas for further consideration.

This larger workshop was held jointly with a SEAMAP meeting (agenda provided in Appendix B). Todd Gedamke (SEFSC) and Jeff Rester (GSMFC) helped represent the NOAA and SEAMAP components of the meeting, respectively. Planning and support for the meeting was provided by Larry Massey, Kerstin Larsen, and Kristin Erickson. The meeting used four small working groups to address specific areas of interest. These working groups were led by James Berkson (VT), Jerald Ault (RSMAS), Gary Fitzhugh (SEFSC), Charles Thompson (SEFSC), and James Nance (SEFSC). Rapporteurs for these groups were Amy Tillman (VT) and Kristin Erickson (SEFSC), Paula Moreno (SEFSC), Julie Neer (GSMFC), and Jim Ditty (SEFSC).

Opening remarks for the meeting were offered by Southeast Fisheries Science Center Director Dr. Bonnie Ponwith. Dr. Stephen Brown (OST) provided background on science funding during the course of the spill. Dr. Daniel Hahn (ORR) spoke on the Natural Resources Damage Assessment process for Deepwater Horizon Incident. Dr. Phil Steele (SERO) provided a review of NOAA efforts to ensure the safety of Gulf of Mexico seafood.

Based on discussions associated with the planning meeting, this workshop focused on collecting ideas to improve regional capabilities in the following four areas:

1) Survey design and statistics;
2) Application of advanced technologies to improve surveys;
3) Leveraging and building effective partnerships for data collection and sharing; and
4) Ecosystem assessment and marine spatial planning.

These areas were viewed as central to the missions of the SEFSC and NOAA in general and would likely be among the core areas needed improve fishery independent survey capacity in the Gulf of Mexico.

The remainder of this document reports on the current status of standard fishery independent surveys in the Gulf of Mexico and provides a compilation of the many important issues noted in workshop discussions. An extended Executive Summary is offered to communicate the major points and suggests avenues for advancing the level of science we deploy in the Gulf of Mexico and perhaps to other areas as well.

Status of SEFSC/SEAMAP – Supported Sampling Programs in the Gulf of Mexico

The NMFS Southeast Fisheries Science Center (SEFSC) and Gulf States Marine Fisheries Commission's Southeast Area Monitoring and Assessment Program (SEAMAP) have partnered to conduct a variety of specialized, multispecies, fishery-independent surveys in the Gulf of Mexico over the past few decades. These surveys generally use either a stratified random or fixed grid systematic design. Gear employed depends on the target species and the habitat expected. These surveys were initiated at various times and each has its own unique time series with respect to spatial and temporal coverage. The primary intent of these surveys was to provide a relative index of abundance for fisheries stock assessments. The following sections briefly describe these surveys. Detailed reports compiled by the SEFSC Mississippi Laboratories are provided in Appendix C.

Plankton Survey

Plankton surveys were initiated in 1977 as part of the National Marine Fisheries Survey MARMAP program. Surveys from 1977 to 1981 in the open Gulf of Mexico in April and May soon proved useful for Atlantic bluefin tuna spawning stock assessment. In 1982 the plankton survey was incorporated into SEAMAP and is now conducted by the SEFSC and state partners.

Today, there are *three dedicated plankton surveys* in the Gulf of Mexico, and these collections are augmented by additional sampling in conjunction with the groundfish surveys. These modern surveys generally date back to the early to mid-1980s, but temporal coverage is variable. Dedicated surveys are conducted in the spring (*April-early June*, targeting Atlantic bluefin tuna, groupers, and *Seriola*), the fall (*August to mid-October*, targeting mackerels, snappers, triggerfish, groupers, and drums), and in the *winter*. The winter survey has not been viewed as a priority and the time series is less well established. Additional collections are made during the summer groundfish survey (June and July, survey targeting mackerels, snappers, and drums), and during the fall groundfish survey (survey targeting drums). Plankton sampling has also taken place during small pelagic, squid, butterfish, reef fish and shark surveys.

The plankton survey design generally covers the entire northern Gulf of Mexico from the 10 m isobath out to the US exclusive economic zone. Recent efforts, particularly in the spring, sometimes extend into international waters. There are approximately 300 stations generally located on a 30 nautical mile systematic grid. Please refer to Appendix C for specific details.

The primary gears deployed on these surveys are the 61 cm diameter bongo fitted with 0.335 mesh nets and the 2x1 m neuston net fitted with 0.950 mm mesh nets. The bongo is fished obliquely from 200 m or 2-5 m from the bottom (whichever is shallower), and the neuston net is fished with one half of the frame submerged (i.e., sampling from the surface to 0.5 m) for ten minutes. The neuston can be fished solo or as a pair of nets (double).

Samples have typically been processed for ichthyoplankton and fish eggs by the Polish Sorting and Identification Center (MIR/ZSIOP). Since 2004, sorting was expanded to cover some invertebrates as well. Typical specimens and data returned from these collections include preserved fish eggs and larvae (generally identified to family), plankton displacement volumes, total egg counts, and counts and body lengths of identified larval specimens. Some species, such as tuna, king and Spanish mackerel, red and vermilion snapper, and gray triggerfish, are specifically targeted for more thorough analyses to support stock assessments.

Groundfish Survey

The two contemporary groundfish (or shrimp and bottom fish) surveys have been conducted annually since 1982. There is one survey in the summer (*June and July*) and one in the fall (*October and November*). The survey domain has been the continental shelf from Mobile Bay west and the number of stations occupied in these surveys was quite variable until 1995. Today 45 stations are occupied. These surveys utilize a stratified random survey design. The summer survey most frequently encounters brown shrimp, longspine porgy, gulf butterfish, rock sea bass, and Atlantic croaker. The fall survey encounters brown shrimp, Atlantic croaker, inshore lizardfish, longspine porgy, and various snappers most frequently.

The objectives of the groundfish surveys are to: 1) provide indices of relative abundance for species occurring between 5 and 60 fathoms (9.14 to 109.73 m) off the coasts of Texas, Louisiana, Mississippi and Alabama; 2) provide indices of the relative abundance for commercial shrimp species off the Texas coast; 3) collect size, sex, maturation and life history data of sampled species; and 4) provide data regarding the extent of the hypoxic zone occurring in the northern GOM.

Reef Fish Survey

A reef fish survey has been conducted since 1996 using three primary gears: 1) video, 2) chevron trap, and 3) bandit reels. These surveys are focused on bank and ledge habitat near the 100 m isobath throughout the Gulf of Mexico. Sampling units are initially randomly selected from 10’ (latitude and longitude) grid cells, but reef habitat is selected and targeted within those cells.

The video equipment used since 2008 consists of four stereo-cameras mounted in a cage and oriented on the horizontal plane at 90 degree intervals. The camera with the best view of the reef is selected as the sampling unit. Individual fish in the field of view are identified to the lowest taxonomic level possible and measured. Counts are used in a calculation providing an estimate of abundance.

Among the most commonly encountered species are red porgy, scamp, almaco jack, red snapper, gray triggerfish, red grouper, greater amberjack, and vermilion, gray, and yellowtail snapper.

Longline Survey

There are two surveys deploying a standardized version of traditional longline gear. These surveys are stratified on the basis of statistical zone and depth and were initiated in 1995. One survey targets sharks and the other targets bony demersal fishes. The shark longline survey most frequently encounters Atlantic sharpnose sharks, blacknose sharks, blacktip sharks, and dogfish (*Mustelus canis*). The bottom longline survey, which covers a depth zone from 9.14 to 365.8 m (5 – 200 fathoms), most frequently encounters king snake eel, red grouper, red snapper, yellowedge grouper, and golden tilefish.

Small Pelagics/Deepwater Survey

The small pelagics survey is a trawl survey using a high-opening bottom trawl. The survey was initiated 2002 to survey the outer shelf and upper slope (110 to 500 m). By 2004, the survey had been modified to better integrate with the SEAMAP survey's shallower focus by expanding the depth range to include depths from 50 to 500 m. Due to gear damage in the east, this survey is constrained to the northern Gulf west of Sarasota, Florida. The survey is stratified on the basis of statistical zone and depth. Most commonly encountered species include long-finned squid, rough scad, wenchman, shortwing searobin, and gulf butterfish.

Survey Design and Statistics Working Group

The survey design and statistics working group was led by James Berkson from SEFSC/Virginia Tech. Amy Tillman (VT) and Kristin Erickson (SEFSC) were rapporteurs.

Working Group Objectives:

- Evaluate baseline data and surveys and assess planning meeting proposals for survey design (e.g. increase effort across the board to reduce coefficient of variability on the CPUE indices, further stratification of existing design, and the addition of a rotating panel approach).
- Suggest innovative survey designs and approaches for data analysis and modeling.
- Identify key covariates and/or additional data needs.

Introduction

In the aftermath of the Deepwater Horizon Incident questions arose from a variety of quarters regarding existing baseline biological data for the Gulf of Mexico available from resource surveys, and methods for detecting change in populations potentially impacted by the spill. These inquiries were recognized as the same as those that arise when any episodic event (e.g., oil spills, harmful algal blooms, hurricanes, cold snaps) occurs in the Gulf of Mexico. During this workshop, data were presented to suggest that a decline in certain fish stocks ostensibly due to a red tide event on the west-Florida shelf was detectable in CPUE indices produced from survey data. Despite this, there remain several unknowns including how such declines might manifest at the population level and how such an increase in local to regional mortality is propagated through the ecosystem. The underlying questions are:

- *Can survey data detect changes due to episodic events? If not, can such capacity be developed?*
- *What can be done to improve surveys in the short term relative to the Deepwater Horizon?*
- *What needs to be done to create an efficient, multi-use survey program capable of providing information to address contemporary and future challenges?*

In the end, these questions were addressed via discussions on three general areas related to survey designs and analyses: 1) an assessment of existing surveys; 2) avenues to improve the analysis of existing data and the development of more effective survey tools (i.e., designs, modeling, and analysis); and 3) securing suitable environmental covariates (i.e., habitat metrics).

Baseline Data Assessment

The basic surveys conducted in the Gulf of Mexico were reviewed and are presented briefly in the above *Status of SEFSC/SEAMAP – Supported Sampling Programs in the Gulf of Mexico* section and in some detail in Appendix C of this document. SEFSC/SEAMAP surveys were generally developed to provide information on age and growth of particular species and to develop indices of abundance for use in stock assessment models. The questions being asked of these data today are clearly not those asked when the surveys were established during the past few decades[2]. However, these surveys provide the baseline data for all efforts moving forward and their value should not be underestimated. Further, maintaining the integrity of these data is important for a variety of reasons, including understanding how the Gulf of Mexico ecosystem may have changed through time.

A variety of analytical techniques (e.g., autocorrelation, variograms and other geostatistical methods) were discussed as methods to help identify trends in existing survey data. Initial attempts to apply these techniques to bottom longline survey data were conducted during the workshop and suggested that autocorrelation between locations seemed to be low or non-existent. However, these analyses need to be repeated under less pressurized conditions than a two day workshop before any conclusions can be reached. Further developments relative to some of these topics are presented in the *Improved Designs and Approaches* section below.

The planning workshop held in Miami in August proposed two general paths forward to address the issue of identifying change due to episodic events. First was a suggestion for a bulk increase in effort such that the coefficient of variation of the catch per unit effort indices (the CPUE indices used in assessment models) would be reduced by 20%. This approach might include increasing effort within the foot-print of the oiled area and some buffer zones surrounding that area, perhaps combined with a dose-response modeling approach. The second suggested path forward involved adopting a secondary survey such as a rotating panel design, perhaps with some fixed stations or partial replacement of fixed stations.

This working group reviewed these options and suggested that:

- Existing survey designs should be maintained during the course of the mandated Natural Resources Damage Assessment (injury assessment) such that sampling is consistent before and after the spill.
    - Changing the survey design risks a loss of continuity, potentially reduced analytical capability, and additional difficulties during litigation associated with the Deepwater Horizon.
    - Survey design must be cognizant of litigation issues to avoid challenges and insure that a jury will understand the sampling program.
    - Increases in sample size and spatial/temporal resolution are advantageous.

[2] Note that this is a continual problem driven by changing pressures in the coastal zone. Surveys conducted today must be adequate to meet tomorrow's challenges and this will require proactive, thoughtful planning.

        - However, Gulf surveys are multispecies in nature and vulnerability to gear is species-specific. This means that pure increase sample size may increase the accuracy and precision significantly for some species, but less so for others.
        - The stated goal of reducing the coefficient of variation by 20% was viewed as but one of many metrics of success that could be developed.

- Augmentation of existing surveys is desirable so long as core components of the sampling programs are maintained without interruption or alteration.
    - Rotating panel and dose response approaches are valid augments, as are a number of other methods to be presented below. The introduction of these programs would be enhanced by analysis of existing data beyond those analyses conducted at the workshop.
    - Dose-response approaches need to be informed by some model of exposure in the environment which had not yet been developed.

Improved Designs and Approaches

Generally, existing data were viewed as potentially suitable for assessing changes in response to episodic events. However, existing analytical methods were not completely in line with some recent advances in statistical theory.

Specifically, survey analyses may benefit by adopting more advanced, computationally-intensive statistical techniques (Markov-Chain Monte-Carlo based methods, hierarchical modeling, Bayesian techniques, dose-response modeling, spatial eigenfunction analysis, asymmetric eigenvector mapping, etc.). Many of these approaches have been successfully employed in other fields and by the USGS Patuxent Laboratory which supports a team of scientists focused on applying a variety of modeling approaches to surveys for cryptic terrestrial organisms such as reptiles and amphibians.

Note, however, that the marine environment is arguably more complicated than terrestrial systems, and some organisms perhaps even more cryptic. Spatial processes in marine systems are often highly structured by oceanographic flows and organism density is estimated only with difficulty. NOAA-Fisheries does not have a single unified Patuxent-like program that focuses on the particular challenges of surveys in the marine environment. Additional staff with the necessary technical skills to take advantage of these types of recent statistical developments and a directed effort to transfer technology and integrate recently developed methodologies from the academic community to NOAA-Fisheries may be needed.

One path forward is to develop a working group composed of academic, federal, and state scientists to facilitate such a technology transfer and advance the science used in designing and analyzing surveys in the challenging environment of the coastal ocean. This group could:

- Examine existing survey techniques and data.
- Develop simulation models for designing optimal survey approaches.
- Investigate the utility of contemporary survey techniques (split-questionnaire, matrix sampling, etc.) for aquatic resource surveys.
- Develop software for use in analyzing survey data.
- Provide training opportunities for fisheries scientists and managers.

Such a working group could focus on regional challenges (i.e., issues relevant to the Gulf of Mexico and Caribbean) or function at a higher level to improve survey efforts nationally thus serving as a primary vehicle for improving NOAA capabilities in this area.

An important consideration is how to build the most effective survey possible given the current economic situation. Not only must surveys provide more information than in the past but they must do so in a highly cost effective manner. A low cost method of gaining knowledge before launching a field program is through simulation modeling. The statistical properties of existing survey data could be assessed and that information used to generate synthetic spatial data for use in exploring proposed sampling programs. The SEFSC revisited these suggestions by holding an additional meeting with Mary Christman, Todd Gedamke, John Walter, Barb Muhling, and John Quinlan. This small group began constructing a framework to accomplish the task. John Quinlan and Todd Gedamke later wrote an internal proposal for support of such work to the NOAA stock assessment improvement program.

Covariates

Most Gulf of Mexico surveys are stratified on the basis of shrimp statistical grids (reporting areas) and depth. The statistical grids are based on lines of longitude or latitude, and depth bins in some surveys can be somewhat broad. This can be contrasted with the surveys conducted in the northeast where the continental shelf has been rather finely divided by many depth-based strata which are each sampled by three randomly assigned stations. Given the variety of benthic habitats, the high biodiversity, the rich water column structure, and the dramatic changes in freshwater discharge across the Gulf of Mexico it is clear that environmental covariates would be helpful in partitioning survey effort more finely than by shrimp grid and depth bin.

Base level environmental covariates could include rugosity, bottom type, slope, bottom albedo, water velocity, biogenic structure, and light. Further partitioning could be driven by water column properties such as temperature, salinity, chlorophyll, turbidity, proximity to fronts, presence of sargassum or eddies, dissolved oxygen, etc. Fortunately, a handful of water column measurements (e.g., temperature, salinity, dissolved oxygen, fluorescence, turbidity) are routinely collected on most surveys. However, these metrics are not often used in the process of developing indices of abundance, and rarely in attempts to stratify surveys. Still, all of these factors could potentially improve our understanding of species distribution. We need to develop the knowledge base to make this information useful and then transition the information to the stock assessment process.

Two areas were identified as potentially providing immediate benefits are:

- Bathymetric/habitat mapping the Gulf of Mexico and/or access to mapping data that has already been collected, and
- The use of acoustic and multibeam technologies for mapping and collecting water column backscatter as a means of estimating distribution and abundance.

Both of these were also mentioned by the *Survey Development Research and Advanced Technologies* working group.

Non-mutually exclusive options are available for obtaining these mapping data. These options include: 1) undertaking the effort within NOAA-Fisheries, or 2) obtaining data access from DOC, USGS, DOI, and/or EPA, and/or 3) partnering with other agencies and industry to produce these data.

Acoustics have been under-utilized in the Gulf of Mexico, but could be helpful for both improving stratification of surveys and for direct estimation of abundance and distribution. It may also be suitable as a survey technique in areas where other methods cannot be deployed. Incorporating this technology into the normal operations of the region is a relatively small cost effort with huge benefits in long run. However, one significant limitation is in the processing of acoustic data and current capacity of the SEFSC to do this work.

Generally, information supporting the delineation of important habitat (benthic and water column) would allow for a higher degree of stratification of the surveys, lower uncertainty in the data stream, and much more efficient surveys. This information was viewed by the working group as valuable enough to make it a priority item.

An additional source of uncertainty arises from systematic changes in the Gulf of Mexico ecosystem. Changes in ocean temperature and dissolved oxygen seem to have occurred and could result in shifts in species distributions. In some cases, species that were surveyed adequately may move to the fringes of the survey area resulting in less effective quantification. There has not been a concerted effort to identify how the Gulf ecosystem has changed since the beginning of the existing surveys[3]. This kind of analysis has provided tremendous insights into system dynamics in the northeast and has helped that area move closer to ecosystem-based management. The same is true of the California Current to Alaskan Gyre region. Understanding the dynamics of the Gulf ecosystem is also important for events such as Katrina and the Deepwater Horizon Incident.

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[3] Barbara Muhling, SEFSC/CIMAS, published an analysis after the workshop (doi:10.3354/meps09540)

Survey Development Research and Advanced Technologies Working Group

This workgroup was co-led by Charles Thompson (SEFSC) and Gary Fitzhugh (SEFSC) with rapporteur Julie Neer (SAFMC).

Working Group Objectives

The group responded to questions developed in the Deepwater Horizon – SEAMAP planning workshop held in Miami (August 25-27, 2010, Appendix A). That workshop identified a need to:

- Identify gaps in survey activities
- Identify under-utilized, but available technology
- Identify barriers that prevent use of these technologies
- Review the value of the current suite life history metrics to identify impacts from a variety of potential perturbations
- Identify new technologies and pilot projects that could advance the region toward ecosystem management and marine spatial planning and thus better prepare us for future episodic events.

Introduction

Fishery independent surveys are an important information source for stock assessments. In most cases, these surveys are also primary sources of information regarding the status of the marine ecosystem. Episodic events, such as oil spills and harmful algal blooms, create demands for information that go well beyond those required by nominal stock assessment activities and well beyond those envisioned when the surveys were initiated.

The Deepwater Horizon Incident underscored the importance of fisheries independent surveys in at least two significant ways. First, stock assessments in the Gulf of Mexico rely heavily on fishery-dependent information. The fishery closures in response to the Incident reduced the flow of information from that data stream. Fishery independent surveys were not impacted in this manner. Second, the Natural Resources Damage Assessment required precisely the sorts of baseline data that can be derived from well designed and consistently implemented surveys.

In a time of greater budgetary constraints the costs associated with collecting samples suggest that we need to ask more from the surveys. We need to revisit how we plan and conduct them, how we analyze the data, and what other bits of information can be extracted from any given sample. Fishery independent surveys should be viewed as a component of the Integrated Ocean Observing Systems (IOOS) infrastructure needed to assess and manage the coastal and marine environment. These surveys need to collect information as efficiently as possible and then interpret that data by synthesizing it with as many relevant auxiliary data sources as possible.

This working group considered the potential uses of survey data, the current gaps in data collection and integration, the occurrence of under-utilized technology and whether under-utilized capacity was present, the barriers preventing deployment, and then offered a series of potential pilot projects that might advance surveys in the Gulf of Mexico. The group also considered whether the currently collected suite of life history variables were suited to address environmental impacts such as Deepwater Horizon and similarly worked to identify appropriate new technologies.

Data Uses

The context of these discussions was initially heavily influenced by the ongoing Natural Resources Damage Assessment for the Deepwater Horizon Incident. Some portion of the injury assessment will involve direct, spatially explicit, quantitative estimates of abundance. This information is input into an oil fate and injury assessment model called SIMAP (www.asascience.com/software/simap/index.shtml). While traditional survey data can supply some of this information, fisheries surveys are primarily geared toward generating measures of relative abundance (indices) that can be used in assessment modeling.

However, contemporary trends toward habitat assessments, which will require metrics such as habitat-specific production rates, and ecosystem-level management, also require information beyond measures of relative abundance. Further, better information regarding abundance and habitat will lead to more accurate and precise indices (assuming this is the least optimistic outcome) for use in Fisheries Management Plan (FMP) assessments. Generally, better information will likely lead to more sophisticated analyses/modeling and improved management. As models improve and we begin reconciling the cost trade-offs of required by increased information resolution, data collection priorities become more apparent. The group identified the following base-level data needs and gaps:

Density/biomass estimates

- These data need to be spatially and temporally explicit and should be size/age structured.
- In contrast to the traditional FMP approach, which requires only relative abundance trends, ecosystem models and damage assessments require quantitative data on organism density. This higher-order data stream plays directly into better assessments and was therefore identified as a clear priority. Acquiring these data will incur higher costs than the collection of relative abundance estimates, but the information will be more useful in a broader range of applications.

Vital rates and physiological condition

- Production rates such as growth, mortality, and fecundity are important for ecosystem management, FMP assessments, and habitat assessments.
- Quantification of consumption rates and trophic linkages can inform management and modeling.
- Generally, a multipronged effort to extract as much information as possible from specimens was supported.
    - Information regarding a suite of vital rates (growth, condition, reproductive status, gender, age, diet, etc.) and health (contaminant loadings, liver condition,

micronucleus presence, etc.) can be derived from individual specimens if sampling and handling protocols are established and funding/capacity made available for analysis.

Classification of species by behavior/habitat/trophic levels (functional groupings)

- The Gulf of Mexico is biologically diverse and some means to deal with system complexity is necessary. Reducing complexity by identifying functional groups, receptor species, etc. would allow for more effective monitoring of Gulf of Mexico ecosystem dynamics. Some suggested methods for dealing with complexity might include:
    - Simplifying the system via the use of functional groups as seen in ecosystem models such as Atlantis, NEMURO, and Ecosim/Ecospace.
    - Changing the resolution of modeled ecosystems such that target species and immediately important processes/species are well resolved while less directly connected processes/species are allowed a more abstract treatment (see US GLOBEC program).
- Suggested methods for handling complexity may include:
    - Redefine/expand organism classification by considering behavior (vertical movements, degree of site fidelity, depth ranges, etc.) to establish species groupings
    - Obtain better information on organism distribution
        - Viewed as more difficult for offshore-deep species than for better known coastal species. However, the Deepwater Horizon NRDA is conducting seasonal deepwater surveys in the northern Gulf.
    - Include economic value, need for special management (species of concern), abundance (detectability), ecological function (engineers, etc.), and sensitivities to particular environmental hazards (e.g., red tides, winter cold kills, petroleum toxicity) in determining groupings or choosing receptor/indicator species.
- It was apparent that greater effort and planning was needed to identify meaningful functional groups and identify indicator/receptor species.

Improved baseline survey data

- There are identifiable gaps common to both ecosystem and FMP approaches.
- A substantial amount of relative abundance information is available from inshore and shelf trawl data (state and federal agencies) and shelf plankton surveys, however:
    - Almost all data are in terms of relative abundance and are not necessarily quantitative measures of density.
    - Spatial coverage can be variable from year to year and from survey to survey.
    - Spatial resolution, especially as it relates to habitat and dynamic physical features, may be less than desired.
    - Temporal coverage could be improved as seasonality is an important ecosystem process and is valuable in the identification of recruitment trends.

- Some species and groups are missing from the fishery-independent surveys.
  - Most of these are either not targeted or not easily surveyed with routine fishery-independent methods.
  - Missing groups include:
    - Schooling pelagic coastal species such as bait fish (herring, menhaden, etc.)
    - Migratory schooling pelagic species such as mackerels. Organisms in deeper waters deeper than 200 m where it is more difficult and costly to conduct surveys, pelagic or otherwise.
- Assessments of economically important habitat-associated species such as reef fish have been hampered by a lack of habitat information and mapping in the Gulf of Mexico. It was noted that this lack of habitat information is generally not well understood except by investigators working in the region.

Benthic habitat mapping and classification

- Habitat mapping was recognized as having exceptional value for ecosystem and spatial management approaches, as well as for improving FMP focused surveys.
- The lack of resolution on the shelf is clearly evident in the most high resolution data bases available for the bathymetry of the Gulf of Mexico.
- Examples of existing programs are:
  - Deep Gulf basin information is available within the public domain but at low resolution (Gloria side scan, http://coastalmap.marine.usgs.gov/gloria/).
  - Although the continental shelf in the Gulf of Mexico is largely unmapped with respect to habitat, small areas (10s-100s of square miles) have been mapped (USGS, http://coastalmap.marine.usgs.gov/regional/contusa/gomex/).
  - Sediment/geological data derived from cores have been used to develop habitat models for fisheries (example given for tilefish and yellowedge grouper assessments).
    - However, these data are available only at relatively low spatial density and do not adequately factor in temporal changes. These data are perhaps best used for broad-scale basin characterization (for background: http://pubs.usgs.gov/ds/2006/146/ and http://instaar.colorado.edu/~jenkinsc/dbseabed/).

Environmental and oceanographic information

- Environmental covariates are important for understanding the Gulf fisheries ecosystem.
- Even simple covariates for fisheries (such as contrasting distributions in brown water vs. green water) are valuable when considering the previously mentioned challenges such as monitoring coastal pelagic species.

- The integration of satellite-borne sensor observations is occurring in some areas (bluefin tuna habitat modeling), but is not integrated in other areas (interpretation of survey data, occurrence of adverse conditions, estimating productivity, etc.).
- The group recognized that the reality for the Gulf of Mexico was that there is not enough “I” in “IOOS” (Integrated ocean observing systems).
  - Cases were related where environmental variables are being recorded and warehoused in data archives but are not yet easily accessible nor applied to fisheries questions.
  - For the Gulf, IOOS activities seem to be split between two organizational systems (GCOOS gcoos.tamu.edu/products/ and SECORA secoora.us/) which appears to result in a lack of cohesion for the Gulf in general.
  - Further, the development of IOOS infrastructure in the Gulf of Mexico appears to lag significantly behind that of other areas in the United States (e.g., existing High Frequency RADAR Sites: http://www.ioos.gov/library/existinghfradarsites.kmz) – this despite the unmatched extent of at-sea industrial infrastructure in the Gulf (e.g., oil platforms http://oceanexplorer.noaa.gov/explorations/06mexico/background/oil/media/platform_600.html) and the high risk for extreme weather (http://www.csc.noaa.gov/hurricanes/#). This issue was underlined by a lack of ADCP and high frequency coastal RADAR coverage during the Deepwater Horizon Incident. Arguably, broad availability of these sensors in the Gulf may have made mitigation of the spill much more effective.
- Similar to a need to facilitate the use of IOOS products, there is a need to create or re-invigorate a clearing house of tagging information (external, acoustic, archival).
  - IOOS and tagging information are inter-related by a need to understand how movements and spatial distributions are affected by changing environmental conditions.
  - A tagging clearing house for the SEFSC exists but has been downsized (see http://www.sefsc.noaa.gov/ctsprogram.jsp).
  - The national IOOS program has moved into animal tagging (http://www.ioos.gov/animal_tagging/welcome.html).
  - Tagging can provide high resolution information on topics ranging from mortality to stock structure and habitat use – all factors that are critical in assessing the impact of episodic events like the Deepwater Horizon Incident.
  - Tagging with environmental sensors can also be a source of oceanographic information.
- As part of the integration challenge, the time and effort required for quality control and synthesis of environmental data streams is large and must be factored into the costs so that this work can be done as efficiently as possible.
- Biological sensors must be incorporated into IOOS. A number of sensors are in R&D stage and need to be pushed into production.
  - This has been an enduring challenge since the early days of IOOS. Another avenue is to utilize ship-board measurements in the interim until fully autonomous biological sensors can be deployed.

Assessment of Ecosystem Health

- Assessing ecosystem health from the perspective of the health status of marine organisms was viewed as a progressive and needed step forward.
- Focused examinations of the health of organisms (bile, liver, reproductive dysfunction, otoliths, gut contents, RNA, etc.) across trophic levels or life history strategies could be added to existing surveys with limited disruption to existing protocols.
- Such collections would enable effective damage assessment in the event of future Deepwater Horizon-like events and would serve as an early warning mechanism for less dramatic chronic challenges.
- Barriers to the development of such assessment capability include:
    - Different events may require different bioassays.
        - A thorough review of the state-of-the-art is required and laboratory studies specific to risks to the Gulf are warranted.
        - Once markers are identified in the lab or via experimentation, they can be related to field surveys.
            - However, the collection of tissues should not necessarily wait for development of lab studies. Tissue banks and available methods can be quite valuable.
- Baseline health conditions in the field must be established and repeat assessments conducted at regular intervals.
    - Challenges identified in these assessments must be investigated.
    - It is noted that the United States has had programs achieving some of these goals (for background see www.epa.gov/emap2/ and water.epa.gov/type/watersheds/monitoring/nationalsurveys.cfm). Unfortunately, these efforts are often of limited scope, insufficient frequency, and, in some cases, have been discontinued.
- The significant challenges associated with the Deepwater Horizon Incident demonstrate that sustained funding, capacity, and more sophisticated monitoring are needed.
- Some biological sampling via fishery-independent surveys could be conducted more regularly, such as increased hard part collection for growth, and increased sampling of tissues for later analyses related to condition or exposure to contaminants.
- New technologies may allow for the rapid measurement of energy density or lipids as well as diet/foodweb linkages (quantitative PCR).

Under-utilized technology

Under-utilized technologies that could contribute to improved fisheries independent surveys and our ability to monitor our Gulf fisheries ecosystem were identified. There were many novel and innovative ideas brought forth by members of the group. The notable limitation to accessing technology was the expected limitations of funding, but the group also recognized that research vessels, facilities (e.g.

calibration tanks) and lack of personnel with appropriate expertise are also limiting factors. However, adoption of these technologies could result in more cost effective surveys in the long run.

Trawl survey gear modifications and development

- Trawls can be instrumented to better quantify efficiency and sampled volume but also to link results to in-situ environmental habitat parameters.
- Need to examine the species-dependence of trawl efficiency factors such as light level and transmissivity.
- How is the net actually fishing? – Better quantification of net opening and swept area would help provide density estimates (needed for ecosystem models).
- What is the net missing? – Recognized need for better understanding of trawl selectivity and fish behavior/net avoidance.
- Trawl depth limitations must be overcome to allow deeper trawling. This could support exploratory work aimed at characterizing the communities potentially impacted by expanded deepwater drilling.
- Additional technologies for deepwater and benthic trawling was identified (10 m^2 MOCNESS, Aleutian wing trawls, beam trawls, etc.).

Plankton survey technology

- Current technology includes bongo, neuston, limited MOCNESS sampling, and CUFES sampling.
- Imaging technology has become quite mature during the past decade and towed instrumentation (VPRII, holocam, habcam, ISIIS), as well as bench-top units (i.e., Zooscan), could significantly improve the precision of larval indices or produce indices of plankton abundance, both of which may be useful in stock assessment models. (Holocam http://www.whoi.edu/oceanus/viewArticle.do?id=82128; ISIIS http://yyy.rsmas.miami.edu/groups/larval-fish/isiis%20website/isiispage1.htm)
- A Manta neuston net is an improved continuous-flow sampler that allows a more quantitative collection of organisms at the sea surface than would a standard SEAMAP neuston sampler.
- High speed plankton sampler – better for enumeration of zooplankton and improving volumetric precision.
- High-speed Digital Plankton Recorders and other imaging instrumentation (ISIIS, SIPPER, DAVPR, VPRII, FloCam) are available and are being deployed as part of the Deepwater Horizon Natural Resources Damage Assessment. These provide a continuous view of larvae in their ocean living space including biotic (predators and prey) and abiotic (environmental) attributes.

Seafloor mapping

- As noted elsewhere in this report, seafloor mapping is one of the priority data needs for both refining surveys and for interpreting historical data. Mapping on the continental shelf in particular is limited. Deeper waters however, which will experience heavier use in the future, are more efficiently surveyed because the swath-width (areal footprint of the measured sea floor) of bathymetric acoustic surveys scales with water column depth.

- The group discussed a two-tier approach to mapping: suggesting course scale for the overall Gulf shelf (e.g. single beam acoustics), then fill in with high resolution mapping where needed. For example, a high cost system (e.g. multibeam) to map sand may be inefficient and unnecessary.
  - Take opportunistic advantage of single beam and split beam ecosounder data for cross shelf efforts. Recent advances in analysis techniques for split beam data show promise for estimating bottom roughness and hardness. Using lower cost acoustical mapping means more entities (state agencies, research teams) could be coordinated for fisheries purposes and could map the shelf more readily using smaller vessels (< 50').
  - Similar to the advances in mapping oceanic fronts, geo-statistical post-processing of acoustic seafloor imagery is available for automating habitat classification which in turn increases efficiency and decreases cost of processing large volumes of data.
  - New technologies such as Synthetic Aperture Sonar have been commercialized and promises high resolution (3 cm) mapping at greatly reduced cost.
  - Synthesize existing data and then approach mapping from a statistical survey perspective where in areas are mapped and treated as representative of larger blocks. These larger blocks would be reduced in size as survey effort was applied over time.
- Increased sediment sampling would prove useful, and in conjunction with optical sensors (e.g. drop cameras, video deployed on AUVs, drift cameras, SeaSled, etc.) may be profitably used toground truth acoustic methods of habitat delineation.
- AUVs are available with advanced imaging capability, optical, acoustic, and standard physical oceanographic sensors.
  - Often these vehicles are more cost effective than traditional surveys and have greater persistence in the environment.
  - These may be beneficial for high resolution mapping.
  - Cooperative multi-unit AUVs which adaptively sample areas are in development and may be useful in providing very efficient sampling of specific areas and features.
- Bathymetric LIDAR and hyperspectral technologies are very promising for mapping large areas of shallow shelf (such as Florida's Big Bend).
  - Because LlDAR is aerial based, large areas can be mapped quickly, but bathymetric LIDAR restricted to about 3X secchi depth. May be good for detecting and mapping shallow reef associated algal blooms and pelagic alga (e.g. Sargassum). Attached alga actually enhances detection of reef locations. Full spectrum light analysis may provide enhanced resolution and discrimination of habitat types (e.g. types of submerged aquatic vegetation, oyster reefs, patch reefs).
  - LIDAR has also been used in efforts relevant to resource assessments for schooling species, large single organisms, and plankton layers. This version of LIDAR is capable of returning information from the sea surface to approximately 50 m in clear water and to 20-30 m in turbid waters. This technology is best deployed as an aerial survey method

and is capable of synoptic surveys both day and night. (http://www.esrl.noaa.gov/psd/technology/instruments/floe/).

Oceanographic characterization

- Characterization of oceanic fronts and water masses, along with other physical and remotely sensed biological characteristics such as algal blooms are critical for understanding the variability of the ocean environment in relation to survey catch variability and may lead to a fundamental shift in our understanding of the Gulf fisheries ecosystem.
- Synoptic frontal climatology
  - Using satellites and *in situ* data, a spatial and temporal characterization of coastal and offshore ocean fronts can be developed.
    - Frontal climatology would be useful in evaluating the effects of the habitat condition in the past for post stratifying the survey catch. Also knowledge of the habitat conditions prior to a sampling cruise would allow one to develop pre-cruise stratification strategies. This is presently done in an experimental manner with the spring SEAMAP ichthyoplankton cruise for bluefin tuna.
    - There is a need for the development of automated techniques to map the fronts. This effort is important due to the time consuming manner of mapping the fronts manually.
- Satellite remote sensing is increasing in spatial and temporal resolution to a scale that is meaningful for classification of sargassum rafts. As optical properties of water constituents become better resolved, algal blooms in general may be better characterized.
  - Ground truthing (collection of *in situ* optical and biological data) is needed as these remote sensing technologies evolve (For background: http://imars.usf.edu/).
- Inter- and intra-annual variability in chlorophyll, temperature, sea surface height and other satellite measured ocean properties can be used to examine the dynamics of the ecosystem and stock productivity (see doi:10.1016/j.jmarsys.2008.10.002), the same is true of atmospheric forcings.
  - Fisheries assessment techniques should be developed to better utilize these kinds of data streams.

Bio- and vital rate technology

- This was an exciting topic of discussion because of new developments that may fundamentally re-prioritize the information we value and the means to collect it. A new generation of biological sensors are being developed that utilize acoustic, optical, genetic, chemical, electrical and other characteristics of living marine resources. In addition, biological sensors are being developed that operate on time and space scales compatible with physical sensors and thus much more likely to be integrated into and increase the value of IOOS for ecosystem monitoring.

- The field of DNA Barcoding (http://ibol.org/resources/scientific-publications/) has made incredible progress in the past few years and now offers techniques that could help discriminate between stocks, unravel foodwebs and even provide identifications of ethanol preserved specimens from just a sample of the preservative from the sample jar. (http://www.biotechniques.com/multimedia/archive/00084/BTN_A_000113362_O_84300a.pdf). Such methods could transform the species identification process, especially in cases where identifications are difficult.
    - Eggs from SEAMAP plankton samples are sorted and archived, but few attempts have been made to identify the eggs for ecosystem-based assessments of fisheries resources. Molecular tools can be used to identify fish eggs for relatively few, targeted species (e.g., real-time PCR) or for complete assemblages (e.g., DNA barcoding).
        - Benchtop auto-processors – about $5000
        - ID is almost 100%
        - Only ID option for most eggs
    - Quantitative PCR and molecular methods are revealing very interesting insights into the diets of krill and larval fishes in the Gulf of Maine and the Arctic and could easily be deployed in the Gulf of Mexico. Work in the Gulf of Maine indicates that about half of the krill diet is comprised of an unknown *benthic* microeukaryote – which means that one of the roles of krill in an ecosystem is to move benthic production to the water column (http://www.sgmeet.com/aslo/sanjuan2011/viewabstract2.asp?AbstractID=9019).
    - A relatively new field, environmental DNA or eDNA - a kind of genetic surveillance technique for invasive species, may have applications for identification of organisms from bulk or environmental samples. (See http://edna.nd.edu/Environmental_DNA_at_ND/Home.html)
    - High throughput DNA barcoding could revolutionize the utility of plankton surveys by providing a rapid means for identifying to the species level the community structure existing in each plankton tow (see http://www.dnabarcoding.ca/).
- Genetic techniques have advanced significantly since the 1990s and are now accepted as a viable tool for stock discrimination. Currently these techniques are being deployed in small-scale lab-by-lab efforts. A more comprehensive approach could involve specific program, perhaps along the lines of the Census of Marine Life (CML), that is specifically aimed at refining the definition of managed stocks. The CML program has already developed considerable technical expertise and some of the infrastructure needed for this work. Leveraging that investment to advance stock and ecosystem management is entirely possible.

Bioenergetics and condition

- Bioenergetics is a key and integrative property for understanding how ecosystems function and a basis for interpreting vital rates such as growth and reproduction. For instance, changes in energy density over time may be reflective of shifts in food web dynamics. There are new and efficient means being developed of measuring energy density and metabolic condition in aquatic animals.

- Bioimpedance, microwave technology, near infrared light technology
  - These methods need to be examined within the context of ontogenetic changes in allocation of energy to growth and reproduction.
- Tagging and movements
  - Potential for direct evidence of mortality and patterns of movement through the use of satellite or acoustic tags.
- Stable isotope signal
  - Obtain background isotope signatures/signal in tissues for particular areas of the Gulf. Animals that move little reflect a 'local' signal, while those that move more may have a "blurred" signal. Thus the degree of isotopic blurring can be related to movement patterns. These methods can also be used to identify food web linkages and the flow of materials through the foodweb (e.g., Carbon-13 as a tracer for fossil hydrocarbons)
- Fluorometer
  - Can provide estimates of chlorophyll concentration, hydrocarbons, productive areas, etc.
- Brevebuster
  - Used detect red tide signatures and representative of a suite of species-specific sensors that are becoming available (http://www.cop.noaa.gov/stressors/extremeevents/hab/features/breve_buster_0506.aspx).

Capacity

- A reoccurring theme during discussion was the need to build capacity in our advance toward ecosystem management. Limits to staffing, ship time, training, and equipment were all viewed as constraints. Along with these, the introduction of new survey technologies requires institutional support (often for several years) before the data streams are useful in stock assessments. In the current economic environment, support for new survey efforts – which may indeed result in increased efficiencies – should not be expected to come from the base funding of the Centers.
- However, there were a few cases considered where existing capacity may be under-utilized. The group identified the need for build effective partnerships with certain entities as a means to enhance our capacity in the GOM.
  - MMS/BOEMRE (as trustee for oil and gas industry):
    - Work with MMS to obtain the release of proprietary and public surficial seafloor information. In some cases this archived information may be purchased at very low cost by agreement with private entities.
    - Work with MMS and industry to use rigs and other infrastructure as platforms for the deployment of acoustics, hydrophones, video plankton recorders, and

other oceanic sensors. It was thought that law already establishes precedent for using wind turbines for this purpose.
        - Work with MMS and industry to use vessels of opportunity (oil industry crew/work boats; cross-Gulf transit vessels, etc) as additional platforms on which to deploy scientific instrumentation. Helicopter transects to oil platforms may be utilized for visual/LIDAR surveys.
        - Work with MMS to develop robust IOOS and hydrodynamic modeling capacity for the Gulf.
    - Department of Defense:
        - Obtain unclassified mapping and seafloor data.
        - Provide advanced technology cross-over from DoD to environmental and fisheries uses. Many experts developing AUV, remote sensing, acoustic, and optical technologies work for DOD. Some experiences of the group members were that development of MOUs and a means to pass funding would allow for collaborative work with DOD researchers.
    - Private and recreational fishing sectors:
        - As with the cooperative research program focused on the commercial fish sector, sentinel fisheries or hybrid fishery-independent surveys for abundance trends could be developed in partnership with the "for-hire" recreational sector.
        - In particular there is a need to seek this sector's assistance to survey coastal pelagic species such as dolphin and mackerel.
        - Development of a collaborative program to collect data (acoustics, SST, profile data) in partnership with participants from these sectors (the NEFSC E-Molt program could be a model).
    - NOAA's office of Ocean Exploration and Research undersea program:
        - Partner with SEAMAP and SEFSC for fisheries and benthic surveys of deep ocean regions, particularly in applying visual and acoustic methods. A Cooperative institute has been developed for the east coast (CIOERT, http://cioert.org). There needs to be a Gulf partnership. Developing a Gulf base of operations would facilitate this (see http://www.nurp.noaa.gov/).

Ideas, pilot projects, and recommended approaches

This topic was enthusiastically addressed by the group in the face of the above mentioned challenges. At more than one point the realization was made that the Deepwater Horizon Incident provided ample justification to jump-start a broader effort for an ecosystem approach to management. A listing of projects is provided without prioritization:

Remote sensing I: Partner with institutions to validate measurements of Sargassum distribution from satellite imagery. This effort may be expanded to other bloom species.

Remote sensing II: Document and analyze the variability in temperature and chlorophyll in the Gulf, especially in association with highly productive areas (Middle Grounds).

IOOS and biology: Develop a pilot array that involves integrated biological and physical sensors based on off-the-shelf products.

Synoptic ocean climatology: A pilot study would characterize and develop climatology of ocean fronts using satellites and in situ data. Part of this study would be the development of automated techniques to map the fronts.

Bioenergetics: A pilot project is proposed to compare technologies developed for field (at sea) determination of lipids or energy density in aquatic animals including: bioimpedance (BIA), microwave technology (fat meters), and near infrared light (NIR) technology.

Ecosystem Health I: A pilot project is needed to review historical data (e.g. from EMAP) and develop offshore receptor species lists and seagoing protocols needed to assess growth, condition, and reproduction in concert with the most relevant bioassays (e.g. bile metabolites for polycyclic aromatic hydrocarbons). This could be a basis for a long-term monitoring effort (e.g. every 5-10 years).

Ecosystem Health II: Develop an initial survey program to collect and analyse various tissues (bile, liver, gonads, stomachs, gills, etc.) to develop a set of baseline conditions. Contrast these data with the locations of known hazards. Given the extensive oil industry infrastructure in the Gulf and the contaminants released in the wake of hurricanes, there may exist considerable structure in health across the system. This program could be combined with seafood safety and routine survey efforts for greater cost effectiveness and maximum use of samples.

Foodweb interactions: Use molecular biological techniques including quantitative PCR to explore the food web linkages across early life stages of fish and zooplankton.

Food web interactions via stable isotopes and micro-elemental analyses: The Deepwater Horizon Incident released a significant amount of ^{13}C and possibly barium into the environment. These, and other tracers, could be used to identify foodweb interactions in the Gulf.

Food web dynamics: A pilot project is warranted to review the merits of various programs underway and develop field protocols for a Gulf food web dynamics program. This should be a basis for a long-term effort to document changes in species interactions as stocks are managed in response to overfishing.

Plankton I: A pilot study to identify the presence/absence of bluefin tuna eggs based on SEAMAP spring survey samples is proposed to test the efficacy of the molecular egg identification method and provide stock assessment biologists with critical information on bluefin tuna spawning locations. In general there is need for R&D support to increase the efficiency of molecular identification of eggs, ichthyoplankton, and zooplankton.

Plankton II: Comparison, cross-calibration and standardization of plankton sampling gear is needed including Standard SEAMAP plankton and neuston samplers, towed imaging samplers, and Manta net sampling system. This calibration has some urgency as all these approaches are underway in the DWH affected area. This effort should also evaluate the use of vessels of opportunity.

Plankton III: Develop a pilot program to employ bench-top imaging for plankton sorting and identification. The program could focus on instrument development and software development for classification.

Habitat mapping I: A pilot project is warranted to evaluate automated classification of acoustic imagery based upon currently operated single beam side-scan systems. Then landscape metrics for reef fish essential habitat can be generated and guide more expensive multibeam and splitbeam mapping efforts.

Habitat mapping II: Following on the above, an investigation into the utility of high end technologies such as Synthetic Aperture Sonar for broadscale, high-resolution mapping.

AUV technology: There is a need to incorporate AUVs for habitat mapping and monitoring of Gulf fisheries resources. The cost-effectiveness for acoustic mapping, and acoustic and optical detection of fish and benthic animals needs to be evaluated. Current glider technology offers a platform to integrate suites of biological and environmental sensors that could provide better data on spatial distributions and environmental linkages at lower cost than ship surveys.

Passive acoustics: A pilot study to determine if passive acoustics can be used to index abundance of some groups of fishes, invertebrates, and marine mammals. This kind of work is ongoing in the Pacific and would have been valuable in the Deepwater Horizon area given the abundance of vocalizing fishes such as croaker on the shelf (for PMELs recorder http://www.pmel.noaa.gov/vents/acoustics/haru_models.html). Note that the Deepwater Horizon NRDA did deploy a limited number of passive acoustic recorders for marine mammal assessment activities.

Gear technology for density estimation: A pilot study is needed to incorporate net sensors to estimate the area swept and the conduct the necessary selectivity and calibration trials. This study would also develop methods for acoustic surveys of deep species. Indeed, net mensuration technologies can and should be ported to existing mission-critical sampling gear in the Gulf where possible.

Movement and migration: There is value in broader examination of fish movements via tagging methods (satellite and acoustic tags) in concert with otolith marker based methods. In particular, pilot studies are need to examine the efficacy of a Gulf-wide acoustic array (e.g., http://www.postcoml.org/) based upon fixed platforms (oil, gas and wind), and otolith chemistry as a biomarker of the spatially-explicit dose from events such as oil spills.

Data Collection, Sharing, and Partnerships Working Group

This working group was lead by Dr. James Nance (SEFSC) with Dr. Jim Ditty (SEFSC) as rapporteur.

Working Group Objectives

The group was tasked with addressing methods to develop effective partnerships on the Gulf of Mexico. Specifically, the issue was addressed by having the work group:

- Inventory existing partnerships, and
- Identify potential conditions that would inhibit effective collaboration and data sharing.

Introduction

There is a need for increased partnership and collaborative data collection, sharing and analysis in the Gulf of Mexico. The Deepwater Horizon Incident clearly demonstrated that effective response, damage assessment, and mitigation is enhanced by working across the boundaries between all stakeholders – including government, academic, non-governmental organizations (NGOs), and industry. Enhanced collaboration will lead to technically improved and cost-effective monitoring and response programs and better science for resource management.

Current or Potential Partnerships

A number of existing organizations exist in the Gulf of Mexico region. Many of these are already partners with NOAA addressing issues directly related to managing the Gulf ecosystem:

1. **Gulf of Mexico Alliance (GOMA)** – State-lead initiative comprised of 13 State and federal agencies. This organization doesn't control research money per se, but has strong outreach component. The Governors of Alabama, Florida, Louisiana, Mississippi, and Texas formalized GOMA in 2004. (http://gulfofmexicoalliance.org/)
2. **SEAMAP** – State / Federal cooperative administered by GSMFC that maintains standardized database of fishery independent data on fish, crustaceans, plankton and environmental information. (http://www.gsmfc.org/default.php?p=sm_ov.htm)
3. **Global Ocean Observing System (GOOS)** – A permanent global system of buoys for observations, modeling and analysis of marine and ocean variables in support of ocean services worldwide. GOOS provide descriptions of present ocean conditions and living resources; continuous forecasts of future conditions; and, information to forecast climate change. GOOS place a high priority on oceanographic information and a lower priority on living marine resources. Texas A&M participates. On the west-Florida shelf, SECOORA seems to be the agency charged with GOOS activities. (http://www.ioc-goos.org/ ; http://secoora.org/ ; http://gcoos.tamu.edu/ ; http://www.ioos.gov/)

4. **Sea Grant Program** – Run under the aegis of National Ocean Service (NOS), with States as partners. Marine extension agent network distributes information to public. (http://www.seagrant.noaa.gov/)
5. **GulfFIN** - **Fisheries Information Network** – $7 million Gulf States / Federal cooperative program established to address various data collection and management deficiencies in the Southeast region. Marine recreational catch and effort data, commercial trip ticket programs, and biological sampling of commercial and recreational catches. Targets 13 species; aligned with collection of fishery dependent data; collects and processes otoliths/spines data and provides metadata. (http://www.st.nmfs.noaa.gov/fis/partnerships/fins.html)
6. **Cooperative Statistics Program** (CSP) - State-Federal-NMFS program to collect landings data from commercial and recreational fisheries. Information used by States and NMFS Southeast Fisheries Center to determine yields, and by the Southeast Regional Administrator and Regional Fishery Management Councils to assist in formulation of Fisheries Management Plans (FMP's). Program is non-competitive with funds provided to State port agents, clerical personnel and statistical supervisors involved in collection and processing of fisheries data. Provides mostly summary data and has metadata component. (http://sero.nmfs.noaa.gov/grants/csp.htm)
7. **MARFIN, SK and Cooperative Research Programs** – Federally sponsored funding mechanisms promotes research to optimize economic and social benefits from marine fishery resources through cooperative efforts of University, State and Federal agencies. (http://sero.nmfs.noaa.gov/grants/marfin.htm)
8. **Gulf and South Atlantic Regional Panel on Aquatic Invasive Species** (GSARP) - Provides a Gulf-wide inventory of biological data on non-native fishes and invertebrates. Also, addresses microorganisms with disease potential within the Gulf of Mexico and near-coastal habitats. (http://www.gsarp.org/#:content@1:links@2)
9. **International Shellfish Safety Committee** (ISC) – Forms ruling body for coordination of shellfish health and safety issues.
10. **National Estuarine Reserve System Program** – National Ocean Service (NOS) program of federal-state partnerships established under the Coastal Zone Management Act creates a system of estuarine reserves for long-term research, education and stewardship of coastal wetlands and estuaries. (http://www.nerrs.noaa.gov/)
11. **Geospatial Assessment of Marine Ecosystem Data** (Gulf GAME) - Florida Freshwater Fish and Game Commission, Fish and Wildlife Research Institute Program. Goals are to identify, inventory, and catalog existing data sets and information related to coastal and marine habitats of the Gulf of Mexico (both in U.S. and Mexican waters) in support of the Gulf of Mexico Alliance Action Plan. Project aims to define and describe marine ecosystems to assist in management of coastal and marine waters that focuses on living marine resources. Also, a metadata repository. (http://myfwc.com/research/gis/game/gulf/)
12. **Gulf of Mexico Program** (GMP) - Initiated in 1988 by the U.S. Environmental Protection Agency (EPA) as a non-regulatory program to provide a broad geographic focus on major environmental issues in the Gulf. A multi-agency partnership that funds research in four major areas: (1) Sustaining Gulf Economy; (2) Improving Gulf Ecology; (3) Mitigating Impacts of

Climate Change, and (4) Mitigating Harmful Effects of Coastal Water Quality. (http://www.epa.gov/gmpo/)

13. **Harte Research Institute** - An endowed research component of Texas A&M University-Corpus Christi dedicated to advancing long-term sustainable use and conservation of the Gulf of Mexico. Components: Coastal and marine geospatial sciences; ecosystems and modeling; biodiversity and conservation; ocean health; marine policy and law; and, socio-economics. (http://www.harteresearchinstitute.org/)
14. **Large Marine Ecosystems** – International organization to coordinate ecosystem research and management in Large Marine Ecosystems globally. (http://www.lme.noaa.gov/)
15. **USGS Biological Resources Division** – Responsible for promoting access to and sharing of biological resource data and information on natural resources within the scientific and academic communities and general public. Has a proactive outreach and education program that funds research in diverse topics within each program area, including threatened and endangered species, and genetics and genomics. (http://ecosystems.usgs.gov/)
16. **Southeast Aquatic Resources Partnership** (SARP) - A regional collaboration of natural resource and science agencies, conservation organizations and private interest groups developed to strengthen management and conservation of aquatic resources in the southeastern U.S. and improve communication among agencies. Offers some grants to support aquatic habitat and fishery restoration and conservation via Community-based Restoration and Aquatic Habitat Restoration programs. (http://www.sarpaquatic.org/)
17. **Bureau of Ocean Energy Management, Regulation and Enforcement** (also known as the Bureau of Ocean Energy (BOE), and formerly as the Minerals Management Service (MMS) - Funds research related to and manages the nation's natural gas, oil and other mineral resources on the outer continental shelf (OCS).http://en.wikipedia.org/wiki/Bureau_of_Ocean_Energy_Management,_Regulation_and_Enforcement - cite_note-about-4 (http://www.boemre.gov/)
18. **LUMCON** – Marine consortium of Louisiana and other Universities (http://www.lumcon.edu/)
19. **Northern Gulf Institute** – Organization which develops, operates, and maintains an integrated research and transition program focused on filling priority gaps and reducing limitations in current Northern Gulf of Mexico awareness, understanding and decision support. Partners with NOAA and five academic institutions (Mississippi State University, Louisiana State University, Florida State University, and Dauphin Island Sea Lab. (http://www.northerngulfinstitute.org/home/ngi.php)
20. **Gulf Coast Ecosystem Restoration Task Force** – Multi-agency program to build on Deepwater Horizon response and Natural Resources Damage Assessment activities to achieve overall recovery for the Gulf (http://www.restorethegulf.gov/)

Data Challenges and Issues

The group identified a number of potential issues that present potential barriers to effective cross-agency collaboration. Some of the issues are:

1. Differences in sampling protocols and data compatibility (species & gear codes), and integration of different types of data
2. Time scale and spatial issues
3. Species names / Common names / Colloquial names, and consolidation, update and data integration
4. State and Federal points of contact for different types of data
5. Issues surrounding whether raw or summary data provided
6. Staff resources to provide data (understaffed)
7. Confidentiality of data, paranoia, risk, and Data Quality Act requirements involved with sharing fisheries data
8. Issues involving a researcher's desire to publish dataset before release of data
9. State by States issues with different data formats
10. Use and abuse of data (improper use of data)
11. Jurisdictional issues and agreements between State and Federal agencies ("Turf Wars")
12. Consistency and quality of metadata among agencies
13. Lack of comprehensive inventory of data sets
14. Continual changes in data media standards and storage
15. Lack of emergency environmental 'preparation drills' among agencies for coordination of effort
16. Need to define 'Data Universe': non-published studies; assessment reports; salt dome studies; etc.

Gaps in Data Collection and Sharing

There were a number of data gaps identified by the working group. They ranged from a lack of trained taxonomists to a lack of basic information in certain locations and in some fisheries.

1. 42 separate fisheries, some with limited background information
2. Circulation modeling and general environmental information below thermocline, especially below 800-m (this is also a concern for continued deepwater oil exploration)
3. Lack of plankton information for State of Texas waters and for other coastal States
4. Spatiotemporal and geographic limitations on data
5. Lack of information on size and age of juveniles; species composition; and patchiness
6. Lack of observations on non-targeted species and by-catch issues by observers
7. Timeliness of data availability by States, Federal government and others
8. Data QA / QC
9. Lack of taxonomic specialists to identify some groups of fishes, crustaceans and mollusks
10. Issues surrounding length / weight conversions
11. Identification of non-standardized data sets among different types of landings data (i.e., head boats)
12. Centralization of data and data sharing
13. Identification and use of ancillary data sets (sediment, oceanographic, satellite, habitat, etc.)

Existing and Potential Model Development

Modeling was extensively discussed in both the ecosystems and advanced technology groups. Here, the group listed three general tasks that would help build an inventory of models, modelers, and applications.

1. Evolution of models, different versions, improvements, enhancements, etc.
2. Inventory / Directory of modelers: Who does what? Differences among models and modelers
3. What is being modeled? Size & Scale – Individual based models or ecosystem models

Mechanisms to expand partnerships:

The primary ways to build effective partnerships include

1. Establishing dedicated, long-term consistent funding
2. Identifying an issue, objective or need for consistent funding
3. Reaching out to other programs to enhance cooperation and dissemination of data
4. Define the 'give and take' or 'benefit' of cooperation among agencies

Additional Partnerships to Increase Efficiency

Data exchange and cooperation can be enhanced via a variety of methods:

1. Establishing mechanisms to share water quality, shellfish and other types of data among agencies and departments, such as DNR, DEQ, and Dept Health and Hospitals
2. Memorandum of understanding among agencies (MOU's)
3. Strengthen / Improve existing partnerships (Don't reinvent the wheel)
4. Better cooperation among physical, biological, chemical, and geological oceanographers and climatologists
5. Fisheries and the Environment (**FATE**) – Adjust RFP call to address / target specific data needs (see http://fate.nmfs.noaa.gov/)
6. Comparative Analysis of Marine Ecosystem Organization (**CAMEO**) - Program implemented as a partnership between NMFS and National Science Foundation Division of Ocean Sciences to strengthen the scientific basis for an ecosystem approach to stewardship of ocean and coastal living marine resources (see http://cameo.noaa.gov/). Program supports fundamental research to understand complex dynamics controlling ecosystem structure, productivity, behavior, resilience, and population connectivity, as well as effects of climate variability and anthropogenic pressures on living marine resources and critical habitats. CAMEO encourages development of multiple approaches, such as ecosystem models and comparative analyses of managed and unmanaged areas (e.g., marine protected areas) that can form a basis for forecasting and decision-making. Program emphasizes collaborations between academic and private researchers and federal scientists with mission responsibilities to inform ecosystem management activities.

Next Steps

In order to further the efforts initiated in this workshops, the group suggested that the following activities:

1. Additional information on Regional Collaboration Team efforts
2. Improved vertical communication within and among agencies
3. Improved outreach to constituency
4. Continue to understand and coordinate jurisdictional issues to increase cooperation among agencies
5. Meet again in one to two years to discuss where we stand and include additional partners
6. Identify ‘Point Man’ and ‘Foot Soldiers’ to maintain the progress and enthusiasm for this effort

Ecosystem Management and Marine Spatial Planning Working Group

The Ecosystem Management/Marine Spatial Planning group was lead by Professor Jerry Ault (RSMAS) with rapporteur Dr. Paula Moreno (SEFSC).

Working Group Objectives

The Ecosystem Management/Marine Spatial Planning group was tasked with four items:

- Identify the principal threats to the Gulf of Mexico ecosystem;
- Identify existing data and models, evaluate their utility to the mission and completeness (spatial, temporal, accuracy, precision) and identify needs in these areas;
- Identify mechanisms to combine data and models and align forces into a comprehensive approach.

Introduction

Integrated Ecosystem Assessment (http://coastalscience.noaa.gov/about/iea.aspx) and Coastal and Marine Spatial Planning (http://cmsp.noaa.gov/) are NOAA programmatic initiative areas and are highly relevant for the Gulf of Mexico. The Gulf possesses a significant amount of industrial infrastructure both at sea and along the coastline. It also has incredible habitat and species diversity, as well as high risk for extreme weather events. Moreover, because it is an enclosed ocean basin in an area that is forced by interplay between El Nino and Atlantic Warm Pool dynamics, it is particularly vulnerable to climate-scale variability – northerly range expansion is not possible for many Gulf organisms. There is a need to assess the risks, identify the various services stakeholder wish to derive from the Gulf, and move toward a recursive management strategy that will intelligently manage the unavoidable increase in development in the coastal zone.

Principal Threats/Forcings Important to the Gulf of Mexico Ecosystem

This discussion area focused on the variety of issues that have the potential to alter the Gulf ecosystem and could therefore be focal points for study, monitoring, and/or management. Overall, the principal issues were derived from six broad areas:

- Exploitation of living marine resources;
- Gulf of Mexico Dead Zone
- Exploitation of energy;
- Urbanization/development in the watershed;
- Episodic biological events; and

- Weather and climate.
- Loss of Protected Resources

Exploitation of living marine resources was viewed as one of the primary manageable drivers of ecosystem variability. Selective removal of species can alter ecosystem function in a number of ways such as by changing the relative weights of linkages between species or by directly changing habitat. The regulation of commercial and recreational fishing, and the reduction of by-catch and post release mortality were listed as primary focal areas. The impact of harvest methods on habitat structure was also seen as a focal area.

Gulf of Mexico dead zone is an area of hypoxic (less than 2 ppm dissolved oxygen) waters caused by nutrient enrichment from the Mississippi River, particularly nitrogen and phosphorous. The dead zone extends from the Mississippi River delta to the mid-continental shelf and westward to the Texas coast. Watersheds within the Mississippi River Basin drain much of the United States, including the major agricultural areas. Nitrogen and phosphorous enter the river through upstream runoff of fertilizers, soil erosion, animal wastes, and sewage. The anthropogenically-enhanced nitrogen and phosphorus levels feed large algal blooms that deplete the dissolved oxygen in the area. The extent of the dead zone varies seasonally and is affected by farming practices and weather events such as flooding and hurricanes.

Energy extraction in the Gulf of Mexico will continue into the foreseeable future and will present continued risks. Types of energy extraction will/may include oil and gas, currents (turbines), wave energy, wind farms, and liquid natural gas. Risks from these societally-demanded activities include discharge of contaminants into the environment, water use for heating and cooling, the introduction of structure in sensitive habitats, the leaching of metals etc. from industrial infrastructure, alteration of the distribution of marine organisms, impingement and entrainment of organisms, loss and alteration of important nearshore habitats for transport, ports and other infrastructure.

Urbanization and development in the watershed of the Gulf of Mexico is unavoidable. This development will result in alteration of freshwater discharge patterns as well as sediment, nutrient and contaminant loadings of waters entering the Gulf via riparian or groundwater routes. Along these same lines, atmospheric disposition (i.e., the 'airshed') of nutrients and contaminants, sometimes from as far away as the Saharan Desert, are an additional non-point source inputs into the Gulf. Development may also result in the loss of nearshore and estuarine habitat.

Episodic biological events such as red tides, disease outbreaks, and introduction of nonindigenous species can have important ramifications for local to regional community structure. In some cases, the genesis of these events could be a combination of natural and anthropogenic factors.

Weather and climate change are known to have tremendous importance and often involve tele-connections between various regions of the world. These processes can result in regime shifts in which a region's entire community structure shifts to a new state. In the Gulf, processes such as El Nino/La Nina, the Atlantic Multidecadal Oscillation, and the North Atlantic Oscillation are known to play a role in short- and long-term environmental variability. Further, the injection of fossil carbon into the modern atmosphere may result in acidification of the ocean – a process that is believed to impact the ability of many important organisms to lay down calcium carbonate structure. Sea level change, altered seasonality, and even the strength of storms and hurricanes have also been associated with fossil carbon use. Coastal inundation, loss of estuarine nursery areas, changes in wind stress and oceanic mixing, shifts in the timing of plankton blooms, and changes in species range are all among the many possible consequences. Recent years have brought winter cold snaps which may be important sources of mortality.

Loss of Protected Resources is a significant and important issue in the Gulf of Mexico and deserves specific mention in this document. The Gulf of Mexico is an exceptionally diverse ecosystem and some 38 protected aquatic species use the Gulf in some manner. Many of these species have very large ranges and use the Gulf as primary nursery areas or as important feeding grounds. These species - and their critical habitats - are subject to a variety of insults ranging from interactions with fishing gear to the physical loss of habitat via pollution, development and other anthropogenic forcings on the system.

The Value of an Integrated Model for the Gulf of Mexico

The next discussion area reported by this working group concerned the utility of integrated ecosystem models for the Gulf. A set of four major areas were identified that covered a range of issues from reconciling multiple-use issues to better accounting of system variability in the management process. This sort of synthetic modeling activity would:

- Assist NOAA and partners in meeting mandated responsibilities through Integrated Ecosystem Assessments, Coastal and Marine Spatial Planning, and Ecosystem Based Management.
    - Ensure compatible uses of the marine ecosystem and avoid use conflicts.
    - Facilitate cohesive, informed environmental analysis and permitting, e.g., NEPA.

- Help characterize and facilitate understanding of the short- and long-term impacts episodic events such as the Deep Water Horizon Incident in a manner that allows for impact assessment and study of the possible alterations to ecosystem services and societal benefits.

- Benefit society by enriching our understanding of marine ecosystems and provide guidance for decision making through DPSIR-type scenario analysis (DPSIR is an acronym for Driving forces, Pressures, States, Impacts, Responses and represents an analytical approach adopted in contemporary Integrated Ecosystem Assessment exercises) by facilitating the analysis of sustainable ecosystem services.
    - Guide restoration efforts by assisting Joint Information Center's efforts.

- Better integrate the effects of ecosystem variability into management decision-making. Address synergistic effects of multiple stressors and multiple management actions/goals. Guide collection and organization of data systems.

Overall, the development of such integrative models would be beneficial. There was, however, discussion regarding the relative merits of different modeling approaches, integration of biological-physical-chemical process, etc. These kinds of discussions highlight the complexity of the task and the fact that many different kinds of models can be developed to address different questions. The group identified the existence of several ecosystem models (Ecosim/Ecospace, Nemuro, Atlantis) each with relative merits and differing data requirements. This discussion could be further informed by those taking place as part of the National Ecosystem Modeling Workshops.

Beyond the details of particular modeling approaches, there is a real need for Integrated Ecosystem Assessment and Coastal and Marine Spatial Planning in the Gulf of Mexico. Rather than continue down a path of continued industrialization, these programs can help facilitate the development of a well managed Gulf of Mexico ecosystem. A well managed system would support desirable ecosystem states, be are free of anthropogenic contaminants, and will not foster the development of undesirable conditions (i.e., contaminated areas, red tides, dead zones, reduced natural production, reproductive dysfunction, anomalous behaviors, loss of biodiversity, increased disease prevalence). Ideally, the management program would possess adequate monitoring to rapidly identify anomalies, have in place decision making processes that allow for rapid assessment of any negative signals in the monitoring data as well as mitigation of the sources of those signals. It would also support multiple, sometimes conflicting, uses with well thought out and equitable planning and enforcement mechanisms in place. And finally a well managed system would utilize partnerships between resource user groups and managers to plan development, mitigate conflicts, and monitor the health and dynamics of the system.

Data Needs to Support Integrated Ecosystem Modeling

The underpinnings of the development of these models are robust data collection and synthesis programs - some of which is described in previous sections. Ecosystem models vary significantly in their need for data. In many cases extensive data are required for estimating numerous parameters. This work group identified a telescoping set of biological, chemical, and physical data requirements that essentially run from physiology to foodwebs and from the local environment to global forcings.

Distribution and abundance: Quantitative, spatially and temporally explicit data on the distribution, abundance, and size-structure of exploited and non-targeted species was a primary concern. Movement patterns, especially in relation to seasonal changes in the system, habitat requirements, and habitat quality were clear elaborations of this basic data need. Many current surveys in the Gulf of Mexico generally produce indices of abundance, rather than true estimates of density. The quantitative nature of these concerns extended to the need to estimate losses due to episodic events such as fish kills.

Physiological Information: Physiology and general metrics associated with health and productivity were identified as data needs. Factors such as energetic efficiencies and potential for compounds to result in endocrine disruption or reproductive dysfunction were identified as concerns requiring additional research and monitoring. Information was desired on body burdens, bioaccumulation, bioavailability, and environmental storage of various contaminants, as well as information on contaminant-receptor dose-response dynamics. One particularly important aspect of these conversations was the mention of examining physiological-contaminant dynamics and transfers across trophic levels. These conversations lead to the suggestion of establishing a NOAA Center for Marine Organism Physiology somewhere in the Gulf. This notion could easily be extended to a well integrated science and monitoring program aimed at understanding organism response to stressors and the levels of those stressors in the field. Perhaps this effort could even move to molecular biological techniques to investigate genetic structure of populations and food web interactions.

Nutrients, Contaminants, and Other Inputs: Identification and quantification of non-point source loadings of nutrients and contaminants from run-off, atmospheric deposition, seeps, and at-sea or shore-side industrial infrastructure was listed as a data need.

Habitat Mapping: Habitat mapping was viewed universally as an important requirement for understanding many ecological processes including various vital rates, trophic transfers, and even the dynamics of fishing fleets. Currently habitat data throughout the Gulf is rather sparse, with some notable exceptions such as the work done in the Florida Keys. Habitat data would include bathymetry, hydrography, the location of fronts – in short a dynamic description of the Gulf environment that moves beyond bathymetric mapping.

Foodweb Linkages: One of the primary data streams required for many ecosystem level models is information on trophic or food web linkages. Trophic linkages change with organism growth, environmental factors such as turbulence, light, or cover, and sometimes can yield incredible insights. For instance, Professor Ted Durbin (URI-GSO) has molecular biological data suggesting that krill in the Gulf of Maine may derive a considerable portion of their energy needs from organisms in the sediments thus providing an important bathy-pelagic link (E. Durbin, personal communication 2010). Although information is available to support some modeling efforts, quantitative data on trophic linkages is a need moving forward.

Physics and Biogeochemistry: Another data need for ecosystem modeling had to do with generating sufficient physical environmental information to support inferences regarding biotic interactions. Nested three dimensional circulation models with appropriate ocean-atmosphere coupling were viewed as one avenue forward, as was enhanced IOOS infrastructure. An open area of research here is the ocean-to-bay modeling much discussed in other venues. Because organisms, nutrients and contaminants flux across arbitrary boundaries, this group viewed such an approach as important.

Economics and Societies: An additional data need was identified in the area of market economics, employment, and sociology. The use of marine resources is partially driven by market forces and the dynamics of communities around the Gulf and around the world. A greater accounting for these factors in the analysis of the Gulf ecosystem was viewed as a currently missing input.

Uncertainty Quantification: The last formal data need had to do with quantifying our uncertainty of the many processes involved in ecosystem dynamics and management. Developing methods to understand the precision and accuracy of surveys, physical models, or even the physiological response of organisms to stressors could advance the sophistication of our management and scientific activities significantly.

Productive Partnerships

The development of an Integrated Ecosystem Assessment or Coastal and Marine Spatial Planning program requires a significant level of coordination between those using the resources. This working group identified a suite of potential partners, more information is provided in another section of this workshop report.

A short list of organizations that should be involved include:

- County, State, Federal, Private Sector and International Partners
- DNRs, DEQ, Universities, NGOs, Fisheries Councils, Chambers of Commerce
- Oil/gas companies, Fishing industry, Tourism, Shipping, Agriculture, Mining, Telecommunication
- ACOE, USGS, NASA, DOI, DOD, EPA, MMS, NOAA, USDA, FDA, DHS
- Mexico, Cuba

Specific Recommendations

Several suggestions were made to help bring to fruition an Integrated Ecosystem Assessment/Marine Spatial Planning program to the Gulf. One of the first steps would be to identify professional staff to organize and shepherd the program along. A second step would be to insure that such a program was supported by a core group of federal and state agencies involved in managing resources in the Gulf of Mexico.

One well supported suggestion to begin this process was the establishment of an ad hoc, but financially supported, "Crunch Working Group." This group would have as a goal laying the scientific groundwork for the establishment of a larger IEA-CMSP program. The group would have a "SEDAR"-type review process to prioritize analyses of databases, facilitate their integration (interface) and make additional recommendations. This group would work 'by correspondence' (webinars and online meetings) to keep costs low and would begin laying the underpinnings to understanding the historical dynamics of the Gulf of Mexico ecosystem and chart a course for the future.

Summary Statement

The US Economic Exclusion Zone of the Gulf of Mexico is a very large area with a diverse mix of habitats, living and mineral resources, and human uses. It is also an area with high likelihood for extreme weather events. This risk, in combination with the extensive shore-based and at-sea infrastructure, results in a degree of fragility that is perhaps unmatched anywhere in the world right now. The Deepwater Horizon Incident dramatically underscored the value of the Gulf of Mexico ecosystem to the region and to the nation. The Incident also provided an opportunity for review of our management practices, discuss the ecosystem including the people of the region, a chance to plan how to restore the Gulf, and also a look toward future opportunities.

Our discussions centered on the activities of Southeast Fisheries Science Center and State partners who have conducted living marine resource surveys to support the stock assessments and management of fisheries and protected resources of the Gulf of Mexico for several decades. This routine monitoring of the Gulf of Mexico literally forms the majority of the baseline data that was required by the Deepwater Horizon NRDA and countless other challenges and developmental programs that the Gulf will see in coming years. Although our working groups focused on differing aspects of the challenge, a common theme emerged: An effective management strategy to address today's challenges and tomorrow's questions will require a considerable investment of planning, time and money to improve how we conduct and interpret our surveys and overall research programs. The opportunity to improve conditions in a significant way lies in front of us.

Appendix A – Planning Meeting Report

Deepwater Horizon - SEAMAP Surveys Planning Committee Workshop

Southeast Fisheries Science Center

Miami, Florida

25-27 August 2010

Miami, Florida

Summary Report

3 September 2010

Sponsored by SEAMAP, the SEFSC, and NOAA Office of Science and Technology

Workshop Terms of Reference

1. Assemble and summarize materials describing the existing fishery independent surveys in the Gulf of Mexico by federal and Gulf state agencies.
2. Summarize the Natural Resources Damage Assessment process and needs.
3. Summarize the current sampling efforts regarding the distribution of oil and dispersants in the Northern Gulf of Mexico.
4. Develop 'strawman' survey proposals for discussion by the full SEAMAP/DWH meeting to be held in September of 2010.
5. Develop and assign tasks that need to be completed before the September SEAMAP/DWH meeting.
6. Discuss framework for advancing Gulf of Mexico ecosystem monitoring and analysis programs.

Note: Highly migratory pelagic species and protected species are not being addressed in this particular workshop

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Workshop Summary Report

1 Introduction

On August 25-27, 2010, representatives from the Southeast Fisheries Science Center (SEFSC), the NOAA Office of Response and Restoration, the NOAA Office of Science and Technology, Texas, Louisiana, Mississippi, Alabama, and Florida, the Southeast Data Assessment and Review (SEDAR), the Southeast Area Monitoring and Assessment Program (SEAMAP), and three academic-sector professional statisticians (Dr. John Hoenig, Dr. Allan Stewart-Oaten, and Dr. Eric Smith) met to discuss the fisheries management and damage assessment challenges presented by the Deepwater Horizon Incident (DWH). The focus of these discussions was to review existing fishery-independent sampling programs in the Gulf of Mexico (GOM), review the spatial distribution of DWH contamination, and discuss adaptation of fishery-independent sampling programs and other environmental monitoring capabilities to address the challenges presented by DWH. This planning committee was convened to discuss the potentially wide range of options that exist and still allow time for data analyses and preparations for a wider audience that will be present at a joint SEAMAP/Deepwater Horizon meeting to be held on September 21-24th in St. Petersburg Florida.

Following opening remarks from Dr. Bonnie Ponwith (Director Southeast Fisheries Science Center) the objectives of both the planning committee and September SEAMAP meeting were discussed. During the first day of the workshop, background information was presented including: 1) a review of existing SEFSC surveys and abundance index calculation methods; 2) a review of the Natural Resources Damage Assessment (NRDA) process and data needs; 3) a review of the physical oceanography of the Gulf of Mexico, sediment distributions, and the extent of the oil spill; 4) several high resolution studies on the importance of habitat metrics; 5) the planned SEAMAP survey for the coming year.

The second day of the workshop had a morning discussion of various potential sampling designs (e.g. stratified random, rotating panel, BACI, radial surveys, fixed-station systematic surveys), and analysis techniques (e.g. dose-response, variogram/mapping, occupancy). Two breakout groups to discuss logistics for the September meeting and sampling design/analysis were held in the afternoon.

The half-day session on the third day was a review of the main topics of the overall meeting, a discussion of tasks that are recommended for completion prior to the SEAMAP meeting, discussions of advanced technologies and potential for spatially explicit fisheries management programs, and the review of two 'strawman' sampling plans that are to be further explored and presented as a discussion topic at the September 2010 joint SEAMAP/Deepwater Horizon meeting.

2 Key Concepts

The overall approach to addressing DWH sampling challenges was initially structured as a two-phase process. The first was an evaluation of a simple increase in sample size given the existing sampling design while the second phase was to discuss new or innovative ideas for sampling strategies that would specifically address DWH impacts. During the course of the meeting a third phase was introduced to address longer term ecosystem and spatially explicit management considerations. It is important to note that the three main phases were not discussed sequentially, nor do they need to be implemented sequentially. Each is discussed in bulleted form below with an expansion of ideas from text submitted by the participants noted in the Appendices.

Overall it was noted that adherence to the existing sampling design was critically important to maintain historical continuity of the data. There was much discussion and some dissenting opinions but generally the group acknowledged that: Phase I would increase the sample sizes of existing surveys and that a rotational panel design for longer term use should be explored; Phase II would consist of higher resolution surveys in the DWH 'impact area' and adjacent survey strata; and, Phase III would consist of pilot-scale work which would refine Gulf of Mexico surveys and move the overall survey program toward spatially-explicit stock assessment and system monitoring to support marine spatial planning/integrated ecosystem assessments. Data analysis and modeling were seen as a necessary ongoing process and one of the underpinnings of the overall program. New analyses and modeling of existing data were encouraged. In addition the development of partnerships with other sectors (academics, industry, other federal and state entities) to pull together multiple data streams and improve overall environmental monitoring was encouraged.

2.1 Phase 1 - Increased Sampling Effort

Phase I sampling was presented as an effort to address immediate stock assessment data needs with the additional benefit of understanding DWH impacts at the scale of the population level (as in stock assessments) for mandated living marine resource management tasks. The following were the key points:

- Increase overall sampling effort to reduce survey coefficient of variation (CV) for key species
    - A reduction in survey CV was identified as necessary to obtain acceptable survey performance for stock assessments and DWH related tasks (see SEDAR stock assessment reports for examples; www.sefsc.noaa.gov/sedar/).
    - The precision of the surveys was discussed in terms of the reduction in CV. Reductions on the order of 20% were initially suggested but the group was clear in that this simply represents 'better' and that exploratory statistical modeling should be conducted to examine the sampling effort required to detect specified changes in relative abundance. The process is complicated by the multiple species managed in the GOM and that an increase in sample size may improve only a subset to 'acceptable' levels.
    - The initial focus was on species in the current Fisheries Management Plan and those which are frequently encountered in the surveys. However, as the meeting progressed, a broader context of considering species that could serve as functional group

representatives, “receptor,” or indicator species for assessing injury was deemed important (see Appendix A).

- Adherence to the existing stratified random approach was seen as appropriate
    - Maintenance of general stratified random was viewed as conducive to a variety of analyses, would not change current sampling design, and would maintain consistency with past surveys.
    - Increased effort should be allocated to strata using existing protocols
        - Subdivision of existing strata was suggested to avoid station ‘clumping’ and to return a survey design that featured a fairly consistent amount of effort per unit area.
    - Potential Challenges
        - Large strata were not considered homogenous in areas with a variety of habitats (both water column processes and benthic metrics) and/or rapidly changing bathymetry .
        - Current strata do not adequately cover the ranges of all species of interest (e.g. tilefish distributions appear to extend into deeper waters than is nominally sampled in the surveys).
        - Some potential impacts of DWH will be in depth ranges from 1000-1400m which are not typically targeted in existing surveys.
        - Subdivision of strata may compromise ‘area apportioned’ distribution of sampling effort to some degree.
- Repeat sampling (rotating panel – Warren 1994), in which a subset of stations visited in one year are revisited in the next, was viewed as potentially beneficial
    - The method will allow paired comparisons across years (See Appendix B).
    - Further investigation is needed using existing survey data to see if useful for all gears employed (trawls in particular).
- Other sampling approaches were discussed but not pursued further in the workshop
    - Adaptive sampling (e.g. work of Thompson) was viewed as untenable in this situation
    - Systematic/Fixed grid potentially presented challenges with some forms of mapping/variogram analyses. John Hoenig stressed that the allocation of additional samples to define variograms and fill spatial gaps in DWH area should be pursued (Appendix B). Additional expertise (e.g. Mary Christman) was recommended for subsequent discussions.
    - Gap-Analysis to ensure adequate spatial coverage was discussed and reservations were forwarded regarding potential invalidation of random stratified base design.

2.2 Phase II – DWH Impact Area Sampling

Phase II was discussed as the component most relevant to the DWH impact area and Natural Resource Damage Assessment activities. The main focus was to investigate ‘local’ effects of the DWH Incident.

- Considerable discussion was centered on the ability to define the 'impact area' given the current 'oil day maps.' (Appendix C). The presence of sub-surface oil has been documented and John Quinlan stressed that the fate of this oil and determination of the potential impact area was highly uncertain. Advection-diffusion-reaction models (circulation modeling) could predict impact area but direct sampling was generally viewed as the best approach. The group felt that it is critical for us to refine our estimates of the 'impact area' as more information becomes available.
- The group also discussed the reduction in fishing pressure that resulted due to closures and the potential impacts on modeling the impact area (Appendix D)
- Jeff Rester noted that the inclusion of the Florida west coast shelf has resulted in a change to the overall SEAMP allocation strategy and results in a lower density of stations proposed for the DWH area in 2010 (Appendix E).
- The impact area and adjacent non-impacted areas will require an increase in sampling effort (Appendix F).
    - The level and timing of the increased effort should be informed by initial statistical modeling using assumptions drawn from existing survey data.
    - Additional effort should be allocated using existing strata.
        - Subdivide strata more finely along depth contours and longitude to avoid 'clustering' in large areas and insure 'even spatial coverage'.
- Dose-Response modeling of the DWH impact area and adjacent areas was viewed as a potentially valuable way forward.
    - Eric Smith, invited for his expertise in these types of analyses, urged the group to "embrace the dose" and focus on this avenue of research.
    - Some concerns were expressed by participants regarding determination of 'dose' (alternatively termed exposure level) but generally accepted that this could be handled
- Species to be considered should be based on abundance in current surveys, ecological or economic significance, and relevance to NRDA process.
    - Greater exchange between NRDA Toxicology study and SEFSC/SEAMAP will help identify species of interest.
    - Species should be closely associated with sediments (nonpelagic component).
    - The use of 'indicator species' was once again highlighted during these discussions (Appendix A).
- Re-occupying stations from last year(s) was discussed in detail (Appendix B). The group agreed that all reef video sites should be resampled and that increasing overall coverage of this survey was advisable. Spatial patterns of increase/decline may be useful for detecting impacts. There was a good deal of pessimism that the groundfish and bottom longline surveys would be suitable due to small scale movement patterns. An investigation of existing data and survey stations in close proximity will be pursued by SEFSC staff.
- Allan Stewart-Oaten proposed simulations of detectablility given simple scenarios and a dose-response model (Appendix G). These models will be a critical component of our discussions on this topic at the September meeting and the SEFSC is grateful for these efforts.

- The use of community structure and ecosystem level indicators was also discussed. Paula Moreno suggested studying the influence of oil contamination on: species richness (S), diversity (H') and evenness; taxonomic assemblage structure; and biomass of functional groups (e.g., top-predators). Another multi-species approach is to examine change in habitat use of the indicator species by comparing niche overlap before/after oil spill disturbance. More elaborate models that examine ecosystem responses to multiple factors (fisheries, oil spill, etc.) may be feasible using tools such as "Atlantis".
- The Deepwater Horizon Incident created a large impact area within which small scale processes are likely important.
    - A recent science paper identifies tendril-like plume that could potentially be missed by current random stratified design
    - A 2009 tilefish study was presented by Gary Fitzhugh as an example that smaller-scale surveys straddling the affected area with process oriented-rather than abundance determination objectives-may serve to evaluate chronic effects such as reduced condition and reproductive capacity in adults. Due to time constraints the group did not discuss this idea, or those submitted by others, in any detail. This is expected to be a component of the joint SEAMAP/DWH meeting.

2.3 Phase III – Toward Spatially-Explicit Management

Phase III developed during the course of the workshop. It became apparent that the necessities involved in addressing DWH for NRDA and assessment purposes will make it possible and more cost effective, to build a more efficient and comprehensive survey program that will support next-generation fisheries and ecosystem management. Overall refinement of the distribution of habitats, incorporation of advance sampling technologies (optics/AUVs, acoustics, LIDAR, habitat mapping, etc.) and environmental monitoring systems (IOOS integration, etc.) were supported and encouraged . Some of the key points of these discussions were:

- Strata heterogeneity was an underlying issue in several conversations
    - Increases in habitat mapping is warranted given the species/habitat diversity in the Gulf of Mexico
    - Collection and analyses of physical/geological (sediment) data along with fisheries data were viewed favorably
- Mapping abundances were viewed as a potentially powerful management tool
    - Determination of variograms/spatial autocorrelation scales for various species and maps of potential covariates should be pursued.
- High risk infrastructure (oil/gas/chemical facilities) and high risk environment (hurricanes) warrant responsive, anticipatory management infrastructure and techniques.
    - Greater involvement of IOOS and cross-institutional collaboration were viewed positively
        - Effective IOOS would allow for immediate and effective response actions in the event of an incident like DWH

        - Circulation modeling could benefit both living resource management and response/NRDA needs, as well as set up effective emergency response capabilities.
    - Greater data sharing and interdisciplinary data collection efforts viewed as necessary
        - Significant data are collected by oil and gas industry, AOML, and IOOS systems; synergistic merging of these efforts could be more efficient and informative
- Pilot scale projects using advanced/underutilized technologies should be investigated further
    - AUVS/Drifters
    - Optics (imaging)
    - Acoustics (both active and passive)
    - LIDAR
    - Telemetry (satellite and acoustic tagging)
    - Gene expression/Biomarker research could be important in relation to DWH (these metrics do not directly demonstrate injury)

3.0 Data Analysis Research and Development

Workshop participants voiced the opinion that there is a variety of approaches for analyzing existing data and any information collected in the future. Currently, stock assessment techniques are geared toward those approaches that have been vetted in the SEDAR process. It was suggested that improvements in how biological and environmental sampling data are analyzed and used is entirely possible and warranted. Additionally, the incorporation of new data stream will enable advances in CPUE standardization and perhaps even allow for the development of spatially-explicit abundance models. Some key points were:

- There is a need to develop better data analysis techniques for surveys and system management
    - Blending of survey data with covariates (habitat, hydrography, etc)
    - Statistical modeling to examine capacity of surveys to detect change
    - Occupancy/Hierarchical modeling should be investigated
    - Dose-Response modeling should be undertaken
    - The development of spatial mapping/variograms is warranted
- There is a need to better define the impact area
    - Oil day maps are not precise representations of oil extent
    - Subsurface oil extent needs better description
    - Subsurface oil in sediments needs characterization
- There is a need to consider incorporating more than one survey in some indices
- There appears to be a need for a science-based proposal process related to long-term DWH investigation (outside the NRDA process) that invites agency and academic studies. This is especially relevant for process studies, mapping and new survey approaches. For example, NMFS Science Box may be a venue for agency proposals but at the time of the meeting it was still unclear whether Science Box was still accepting proposals.

4.0 Data Management and Quality Control

As the amount of data increases, robust and accessible data management systems will be required. If data are intended for use in the NRDA process, then certain protocols must be followed. Under any scenario, quality control and documentation will need enforcement. Because future data streams will be more voluminous and interdisciplinary, the overall data management system needs to be evaluated.

Appendices

Deepwater Horizon - SEAMAP Surveys

Planning Committee Workshop

Appendix A.

The use of indicator species to detect impact of the DWH event

Gary Fitzhugh

The need to identify certain indicator (receptor) species came from discussions within the NRDA fish technical working group that resulted in a draft strategic plan (May, June 2010). It was recognized that some simplified approach was needed to assess injury to such an expansive and complex system with high species diversity. Thus a limited number of receptor species were proposed to serve as representatives of habitat zones (1. Abyssal/mid-water pelagic, 2. Deep benthos, 3. Surface mixed layer, 4. Neuston, 5. Shallow pelagic, 6. Nearshore waters 7. Intertidal/subtidal and 8. Freshwater/brackish) and functional groups (herbivores, omnivores, detritivores and piscivores). Consideration of habitat zones and the functional groupings nested within them could illuminate pathways of injury related to diet and physical exposure. In addition other criteria could be important including economic value (harvested species), ecological importance (species of concern), and those species known to be susceptible to oil-derived contaminants. From this background a near-shore receptor species list was compiled (Table 1). Consideration of offshore species was also important but the number and types of offshore species and habitat associations are much less commonly known. Thus a second list of candidate offshore species was drafted based on consultations with several biologists knowledgeable about surveys and the biology of certain offshore groups (NMFS Panama City and NMFS Pascagoula, Florida FWC, and Gulf Coast Research Lab) (Table 2). In considering the lesser-known offshore species, another consideration was that the indicator species should be abundant enough to be commonly detected by surveys in the affected area.

Table 1. Nearshore receptor species. Extracted from NRDA Fish Technical Working Group Strategic Plan.

Grouping	**Species**	**Rationale**
Benthic Macro-invertebrates	Blue crab (*Callinectes sapidus*)	Benthic omnivore, planktonic larval stage, economic and societal importance. Crabs are commercially and ecologically important crustaceans that are likely to be impacted by oil as it moves inshore. Larval stages that are recruiting or out migrating juveniles may be especially vulnerable
	Gulf shrimp (*Litopenaeus sp., Farfantepenaeus sp*.)	Benthic omnivore, planktonic larval stage, economic and societal importance. Shrimp are commercially and ecologically important crustaceans that are likely to be impacted by oil as it moves inshore. Larval stages that are recruiting or out migrating juveniles may be especially vulnerable
	American oyster (*Crassostrea virginica*)	Benthic planktivore, planktonic larval stage, subject to bioaccumulation, oyster colonies provide habitat for other species especially in the northern and eastern Gulf, economic and societal importance. Oysters are commercially and ecologically important shellfish that are likely to be impacted by oil as it moves inshore.
	Florida spiny lobster (*Panulirus argus*)	Benthic omnivore, planktonic larval stage, economic and societal importance.
Herbivorous Fish	Gulf menhaden (*Brevoortia patronus*)	Important nearshore baitfish positioned low on the food chain. Particularly in northern Gulf. Aka; "Pogy" Commercially important for fishmeal and other fish byproducts. May be sensitive to environmental perturbations.
	Ballyhoo (*Hemiramphus brasiliensis*)	Important shallow water baitfish placed low on food chain. Particularly in central and southern Gulf (i.e., South Florida and Florida Bay).
	Striped mullet (*Mugil cephalus*)	Important nearshore baitfish and foodfish. Detritivorous and herbivorous positioned low on food chain. Important for observation as foods and feeding habits are both near the bottom and at the surface.
Piscivorous Fish	Red drum (*Sciaenops ocellatus*)	Important nearshore sportfish. Piscivore. Offshore spawning occurs in somewhat deepwaters within ~10 miles off the coast meaning this species migrates seasonally from shallow to deeper waters.
	Spotted seatout (*Cynoscion nebulosus*)	Important nearshore sport and commercial species. Piscivore. Spawns nearshore, with juveniles using seagrass beds and adults using oyster reefs as an important habitat (direct ties to SAV and oyster plans)
	Common snook (*Centropomus undecimalis*)	Important nearshore sportfish. Piscivore. Occurs throughout northern Gulf, but more common in South Florida.

Flatfish	Gulf flounder (*Paralichthys albigutta*)	Shallow water benthic species. Commercially and recreationally important. Juveniles use seagrass beds. Documented health effects associated with PAHs (lesions, liver tumors, etc.)
	Southern flounder (*Paralichthys lethostigma*)	Shallow water benthic species. Commercially and recreationally important. Juveniles use seagrass beds. Documented health effects associated with PAHs (lesions, liver tumors, etc.)
Shallow Coral	Blue Parrotfish or other species	
Freshwater and Diadromous Receptors	Gulf sturgeon (*Acipenser oxyorhinchus*)	Large anadromous fish with federal protection (threatened).
Miscellaneous receptors	Jellyfish, ghost shrimp etc.	These may be included as opportunistic receptors due to observed die-offs etc.

Table 2. Candidate offshore receptor species for assessing ecological injury. Consulted references are denoted by number in the Rationale.

Grouping	**Species**	**Rationale**
Surface waters/Sargassum community finfish	Dolphin, (*Coryphaena hippurus*)	Carnivore, targeted for harvest, economically valuable, Gulf-wide. 4,5
	Flying fish sp., Exocoetidae	Planktivore, abundant, important prey for pelagic species, Gulf-wide. 2
Surface waters/Sargassum community macro-invertebrates	Sargassum crab, (*Portunus sayi*)	Gulf-wide. 3
	Sargassum shrimp, (*Latreutes fucorum*)	
Depths < 200 m, Pelagic fish	Atlantic bumper, (*Chloroscombrus chrysurus*)	Planktivore, important prey species, Gulf-wide, to 55 m. 1,4
	Greater amberjack, (*Seriola dumerilli*)	Piscivore, abundant, game and food fish, Gulf-wide, generally <70 m. 2,4
	Blue runner, (*Caranx crysos*)	Carnivore, abundant, Gulf-wide, generally <100 m. 4
	Crevalle jack, (*Caranx hippos*)	Piscivore, abundant, Gulf-wide
	Round scad, (*Decapterus punctatus*)	Planktivore, abundant, important forage. 7

Depths < 200 m, Demersal fish	Red snapper, (*Lutjanus campechanus*)	Piscivore, highly targeted for harvest, economically valuable, Gulf-wide. 1
	Atlantic croaker, (*Micropogonias undulates*)	Omnivore, common, dominant interactor in demersal food web, economically valued, Gulf-wide. 1,7
	Sand perch, (*Diplectrum formosum*)	Omnivore, important prey species, Gulf-wide to 80 m. 1,7
	Dusky flounder or shoal flounder (*Syacium papillosum or S. gunteri)*	Omnivore, abundant benthic species. 1,7
	Lizard fish, (*Synodus* sp.)	Piscivore, abundant. 1,7
	Red porgy, (*Pagrus pagrus*)	Carnivore, common in recreational fishery. 1,7,8
	Pinfish, (*Lagodon rhomboides*)	Omnivore, abundant and important link between estuaries and continental shelf. 1,7
	Tomtate, (*Haemulon aurolineatum*)	1,7
	Longspine porgy, (*Stenotomus caprinus*)	1,7
Depths < 200 m, Migratory fish	Little tunny, (*Euthynnus alletteratus*)	Piscivore, Important prey for large pelagic species.
	Skipjack tuna, (*Katsuwonis pelamis*)	Piscivore
	Atlantic sharpnose shark, (*Rhizoprionodon terraenovae*)	Piscivore. 1
	Yellowfin tuna, (*Thunnus albacores*)	Piscivore
	King mackerel, (*Scomberomorus cavalla*)	Piscivore
Depths < 200 m, Pelagic macro-invertebrates	Arrow squid, (*Loligo pleii*)	1
	Longspine swimming crab or Iridescent swimming crab, (*Portunus spinicarpus or P. gibbesii*)	1,3
Depths < 200 m, Demersal macro-invertebrates	Mantis shrimp, (*Squilla empusa*)	1

	Brown rock shrimp, (*Sicyonia brevirostris*)	1
Depths > 200 m, Pelagic fish	Gulf butterfish, (*Peprilus burti*)	1
	Lanternfish, Myctophidae	Planktivore
	Bristlemouths, (*Cyclothone* sp.)	Planktivore
	Rough scad, (*Trachurus lathami*)	Planktivore. 9
Depths > 200 m, Pelagic fish	Skates, Rajidae	Omnivore
	Tilefish, (*Lopholatilus chamaeleonticeps*)	Omnivore
	Yellowedge grouper, (*Epinephelus flavolimbatus*)	Piscivore. 1
	Luminous hake, (*Steindachneria argentea*)	Omnivore. 9
	Wenchman, (*Pristopomoides aquilonaris)*	Piscivore, often reef associated but schooling above bottom. 9
Depths > 200 m, Demersal macro-invertebrates	Royal red shrimp, (*Pleoticus robustus*)	
	Geryonid crab, (*Chaceon quinquedens*)	9
	Golden deepsea crab, (*Chaceon fenneri*)	
Depths > 200 m, Pelagic macro-invertebrates	Longfin Inshore squid or broad-tail shortfin squid, (*Loligo pealei or Illex coindettii*)	9

1. SEAMAP Biological Atlas 2005, 2. Hoese and Moore. Fishes of the Gulf of Mexico, 3. online SEAMAP portunid guide, http://www.gsmfc.org/seamap/picture_guide/Crabs/portunus.pdf, 4. Wikipedia, 5. Robins, Ray and Douglas. Peterson Field Guide Atlantic Coast Fishes, 6. Humann. Reef Creature Identification Florida Caribbean Bahamas, 7. 2009 FWRI SEAMAP Data, 8. FWC Fisheries dependent monitoring staff, pers. comm., 9. Deepwater pelagic data, Pascagoula Lab, pers. comm.

Appendix B

Three options for modifying fishery-independent sampling in the Gulf
John M. Hoenig

1) Use partial replacement of stations to enhance the ability to detect changes in a population;
2) Allocate additional stations to fill in the spatial coverage in areas that were exposed to oil and in adjacent areas in order to facilitate mapping of abundance of fishery resources in relation to maps of oil exposure;
3) Allocate additional stations to enhance the ability to study spatial autocorrelation, i.e., to estimate semivariograms.

In order to evaluate these options, the following work could/should be attempted before making decisions about modifying existing programs.

- Existing data on spatial autocorrelation should be examined to see what can be inferred about the nature of semivariograms, e.g., existing data are inadequate, existing data provide good semivariograms with a long or a short range and a large or small nugget.
- Existing data should be examined to find sites within x km of each other that were visited in successive years; these data should be used to see the level of correlation, where a variety of values of x are examined (the greater the value of x the more pairs of observations but the weaker the correlation because of spatial variability).

Justification for proposing these options is as follows.

Partial replacement of stations. There are two reasons for proposing reusing some stations for more than one year. 1) If there is spatial persistence (good stations remain good and bad stations remain bad over time) then increased precision in estimates of change in population size can be had because a source of variability (location) is controlled for. 2) If oil has had a negative impact on abundance in a region then before/after paired observations may be the most efficient way to estimate the degree of change.

Allocating additional stations to enhance estimation of the semivariograms. In order to estimate a semivariogram one looks at squared differences in catches as a function of distance between the observations. To obtain good results it is necessary to have observations that are separated by small, medium and large distances. The allocation of additional stations can be used to insure there are enough observations in close proximity. If autocorrelation exists over a large enough range of distances then maps of abundance can be obtained in addition to estimates of (relative) stock abundance.

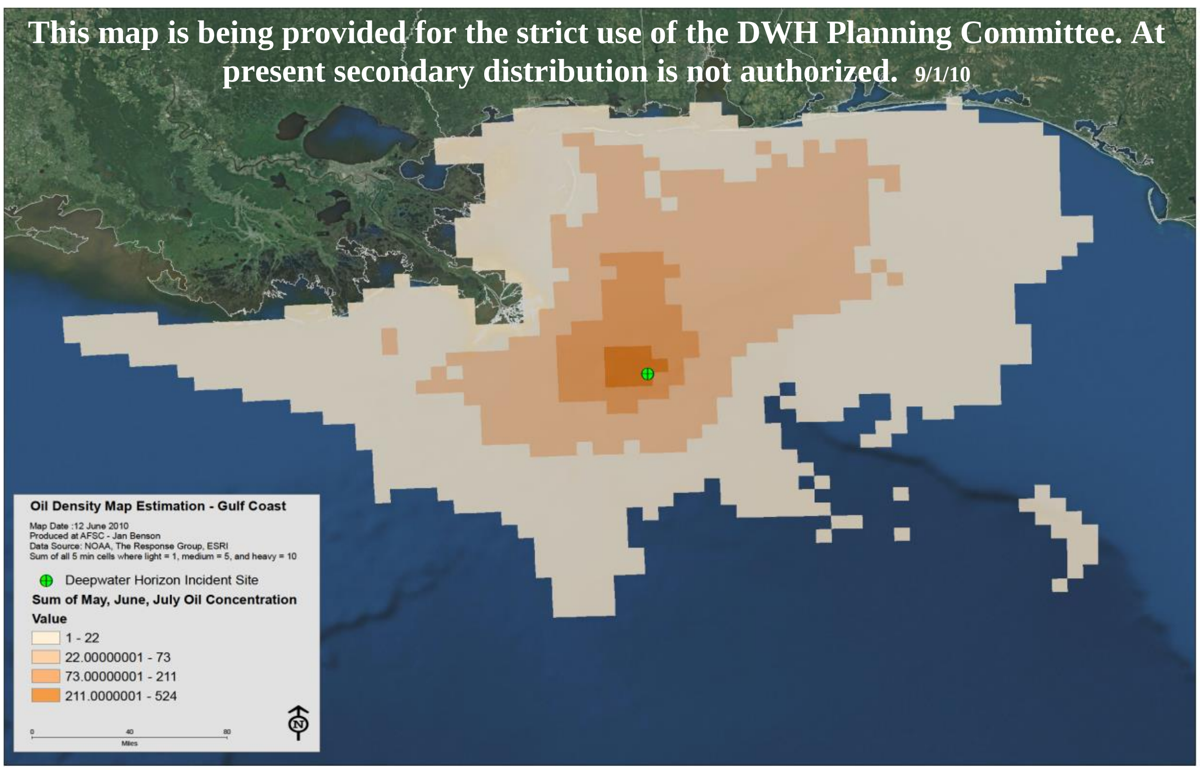
Allocating additional stations to fill in spatial gaps. This activity is worthwhile IF spatial autocorrelation exists over a large enough spatial scale. If so, the allocation of additional stations is needed to extend the range over which reliable maps can be made. This has two applications: 1) to map resource distribution in relation to oil contamination, and 2) mapping resource distribution in succeeding years as part of the stock assessment process.

Appendix C

Map of surface oil concentration estimation:

Paula Moreno

AFSC (Alaska Fisheries Science Center) produced a map summarizing oil density on a grid of 5-minute by 5-minute cells over the course of several months (see Figure below). This map represents the number of days that cells were oiled weighted by the severity of oil concentration (light = 1, medium = 5 and heavy = 10) and is based on the daily forecast trajectories (NOAA/NOS/OR&R). There is a need to obtain an update of this map to include all the months covered by the trajectory forecasts with non-blank maps (May through early August). In addition, it may be useful to develop a map that compiles information from all available sources (federal agencies, universities, industry, etc.), including observations and simulations of oil concentration and dispersion from the bottom to the surface. Note that the map below does not take into account “beached oil” produced in the forecast trajectories.

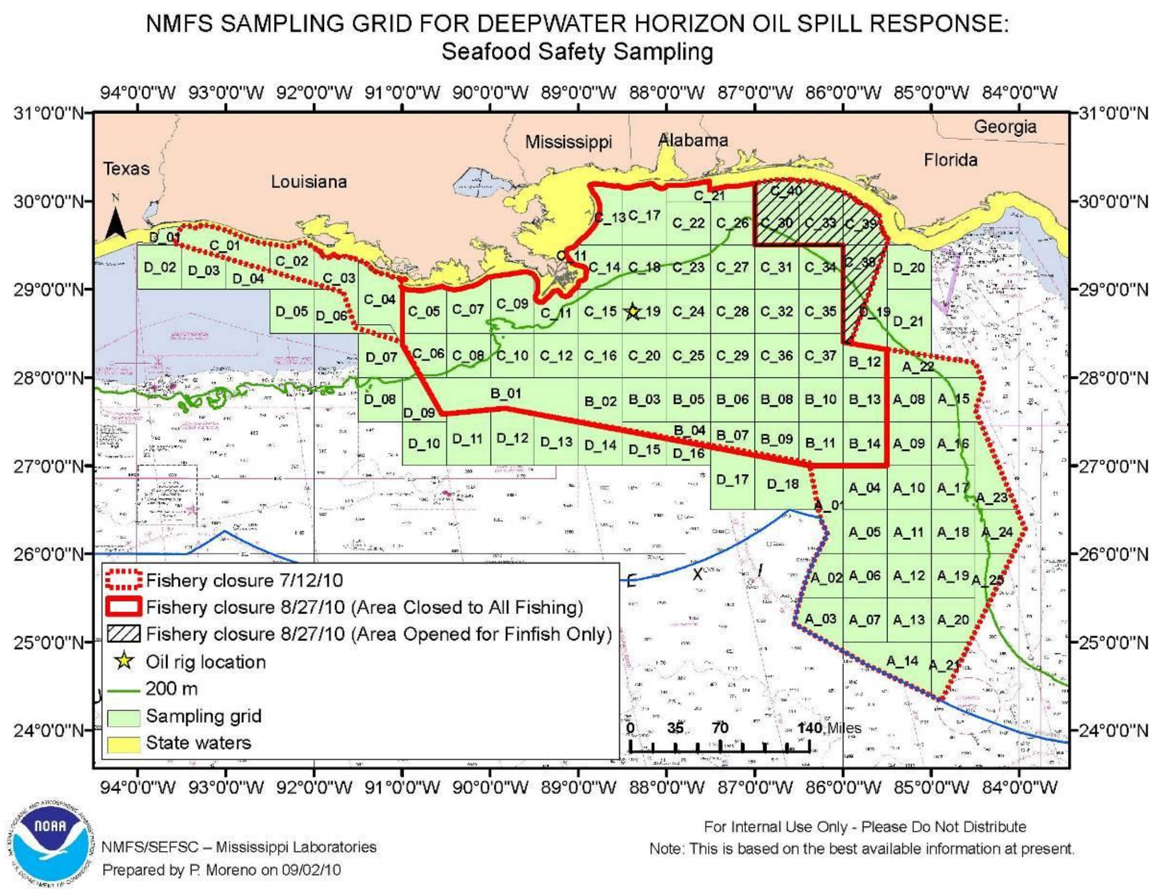


Appendix D

Response Cruises:

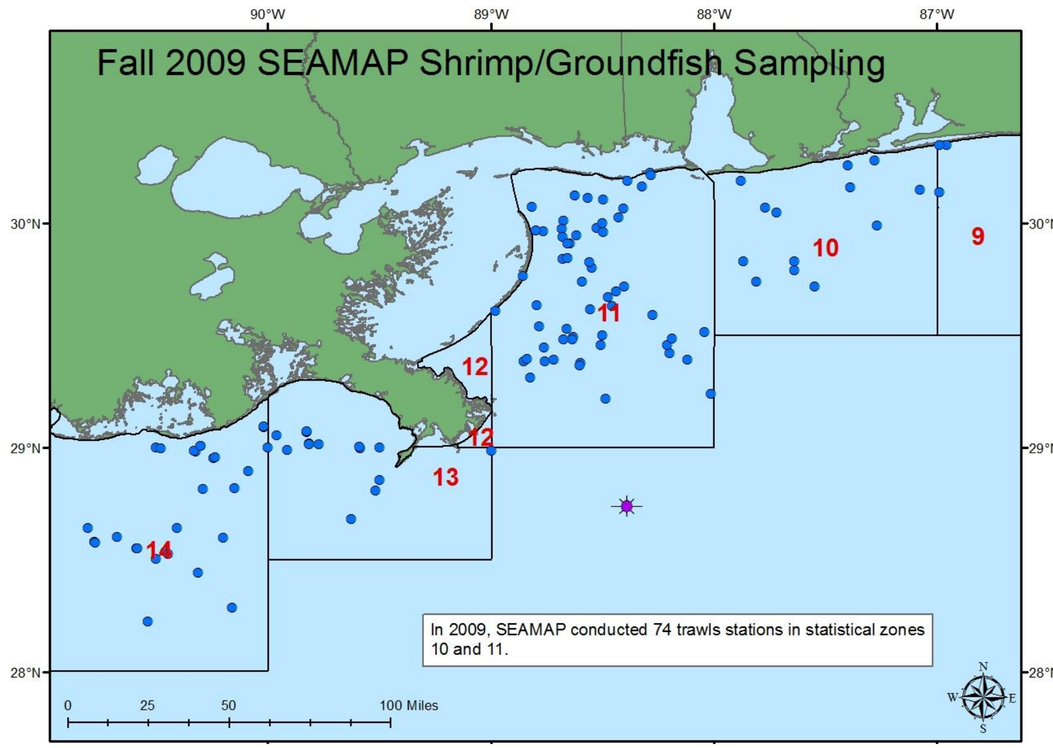
Paula Moreno

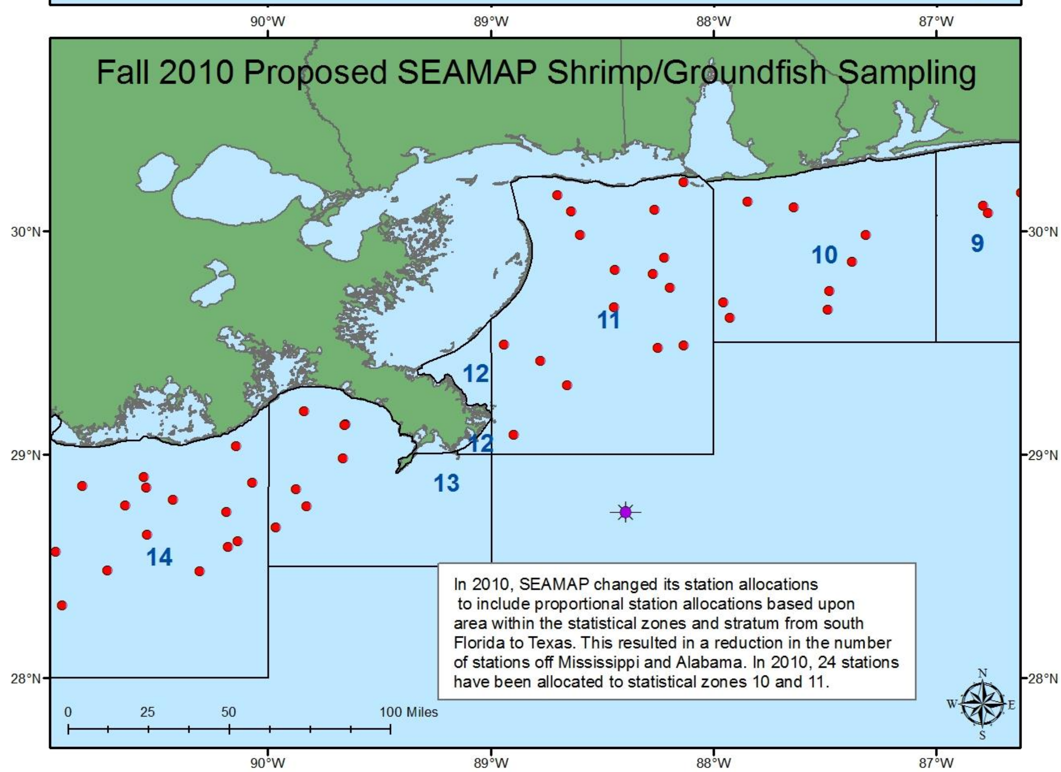
Response cruises consisting of baseline, seafood surveillance and fisheries closure re-opening sampling have been conducted by the SEFSC, Mississippi Laboratories since the DWH incident occurred to collect baseline data on species distribution and specimens for seafood safety analysis. Sampled specimens are subject to chemical and sensory analysis conducted by the National Seafood Inspection Laboratory (NSIL). Baseline surveys were conducted in areas where oil is absent. The figure below shows the sampling grid that is currently the main focus of the response cruises. The subsequent figure shows the location of sampled stations. While these surveys are not designed for population level assessment, the use of data collected during these surveys may be useful as a complement to other sources of oil contamination data used in determining the "impacted area".



Appendix E

DWH area specific SEAMAP stations (2009 and 2010) - Submitted by Jeff Rester (SEAMAP)





Appendix F

The need for additional samples in the oil impact area

Eric Smith

Statistical impact assessment methods involve comparison of sites within an area designated as impact and those designated as not impact or the use of a model relating the “dose” from the impact to a response. The strength of the comparison depends on the number of sites, samples at those sites and the location of the samples within the impact zone. In general, the smaller of the sample sizes determines the precision or power of comparison (impact with non-impact) or the precision of the model. For a fixed total sample size the best situation is one where the sample sizes are balanced between the areas.

The current fisheries sampling plan involves sites throughout the Gulf within certain depth limits and is disproportionately focused on areas likely to be not impacted or slightly impacted by the oil spill. By increasing the number of samples within the area likely impacted, the sampling program will be much more likely to detect effects of the oil spill if there are any. The additional sampling will allow for better spatial coverage of the area and also will allow for the estimation of a broader variety of models, with greater precision.

The best way to increase the number of samples depends on the pattern of impact over space. Without this information, a reasonable way to allocate samples within the potentially impacted area is to subdivide the existing strata into sub-strata and randomly sample within the substrata. Additional samples within the potentially impacted area, if selected by segmenting (longitudinal division of depth classes within spatial strata) current strata into substrata will not affect estimates of parameters important to the current program (i.e. estimates of quantities under the adjusted sampling strategy may still be used to compare years). The samples will no longer be proportional to size so the design is sub-optimal relative to the best design however the overall precision should be greater than if additional samples had not been taken.

Below is an example to illustrate that balance improves estimation of power. In this case, we assume there are two areas, one designated as impact and one as non-impact. To compare the areas, a two-sample t-test is used. If the standard deviation is 20 and the mean catch in the impact area is 10 while that in the non-impact area is 20 then the power is 0.508 if the number of samples is 20 in the impact area and 80 in the non-impact area. If the sampling is balanced (50 in each area) then the power will increase to 0.697 which is roughly 40% better.

Appendix G

Proposed Simulations for Dose-response/impact scenarios.

Allan Stewart-Oaten

Information needed: (a) Map showing where the strata are. (b) data on a fish species; I assume with columns Date (or Year), Stratum, Count. (Maybe sample number, since each stratum has several samples each year.) (c) data on oil exposure, with columns Stratum and Exposure. The "exposure" might not be numerical - e.g., High, Moderate and None.

Simulation: (a) Generate Kn numbers per stratum, to represent the next samples. n = number of samples per stratum at present. K = number of substrata per stratum in future sample; we've talked of 2 or 4. The number K may apply only to some strata, e.g., the ones we think are in areas of high oil contamination, with K = 1 for other areas. We could use something more elaborate, like K = 4 in High Oil areas, K = 2 in Moderate Oil, and K = 1 in No oil. (b) Each new number is generated from a "Delta-LogNormal" distribution, with parameters p = Prob{Count > 0}, m = Mean of lognormal, and s = SD of lognormal. (c) In each stratum, these parameters depend on the Before data and on the oil spill map.

Choosing parameters. There are many ways to determine them, but most would use (i) an estimate of what the parameters would have been without the oil spill, and (ii) an "effect" of the oil spill that reduces p or m or both. For (i), the simplest version would assume the same values of p, m and s for every stratum, and estimate them as if the Before data were uncorrelated over both time and space - unrealistic, and even here we might want to remove depth strata where the given species is never observed. A more complicated version might assume that each stratum has "true" values of these parameters but each year's values = true values + deviations, where the deviations are generated by a process which has some variance (estimated from the Before data) and maybe some correlation over space and time (though this seems to be weak). For (ii), we concoct functions f(Dose) and g(Dose) for "effects" on the p, m and s parameters. If p, m and v are the parameters that stratum would have had without the oil, then (say) f(Dose)*p, g(Dose)*m and g(Dose)*s would be the corresponding values with the oil. Sensible choices for f() and g() could be guided by people who know something (i.e., not me!) though I suggest we might want to look at some cases where f = 1 (no effect on the number of zeros, only on the mean and SD) and some where g = 1 (the reverse), as well as mixtures, and that we might want to make the functions fairly extreme (i.e., f or g near 0 for High Doses) so we get an idea of the accuracy of our estimates and ability to distinguish them from "no effect". If the Dose is High, Moderate or None, then f() and g() are rather simple - each has only three values (or fewer, e.g., if f = 1). If Dose is numerical, we could use something more elaborate - or would this be overkill?

Analysis:

(a) Essentially this requires a model giving the distribution of all the Count values, with some parameters that appear throughout, and some others that appear only for the "next year's" Counts, and represent the "effects" of the oil. We then use the "data" (the Before and the simulated After) to estimate these parameters (with error bars), probably by maximum likelihood. There are many possible such models: the "Choosing parameters" section above applies almost unchanged. We might also want to use only some of the Before data, such as the most recent year only. (I think this might be questioned because it ignores temporal variation - it basically says "even with temporal variation, the chance that the oiled areas would have dropped by so much more than the unoiled areas is small, so it's likely to be due to the oil." That's not a bad argument unless we find that changes between years have tended to be correlated over space.)

(b) We might want to mix and match the simulation and analysis models. That is, we generate the simulated data by one model (like the one that assumes all strata and years are independent with the same p, m and s) and analyse the data by the same model, or by a model that allows parameter values to vary over strata and years by some kind of deviation model (see (i) of "Choosing parameters"). Usually, I would expect that, for a given simulation model, the analysis that uses the same model will give the best results (in some sense, maybe least square error, though we might want to take the accuracy of error bars into account as well); using an analysis model different from the simulation model corresponds to model misspecification, an error we are highly likely to commit in practice, and should give less pleasing results.

(c) These analyses compare sites with different Doses (amounts of oil). If there is a "Response", it could be due either to declines in life history parameters (fecundity, survival) or to fish moving away from oily areas while the total stock is unaffected. A way to separate these is to estimate the Before - After change in the total population, combining all strata (oiled or not). The simplest method is a t-test (or t-confidence interval) with the Before totals as one sample and the After total as the other (a sample of one!).

Writeup: We will want some way of describing the results of these simulations and analyses, probably by tables but maybe by maps also. How we do this depends on the models we use and maybe on the results we get. The need to get reasonably clear messages suggests that the simulation and analysis models should not be too elaborate. For example, the "effect" models should be fairly easy to put in order: one basic model might be f() = 1 and g() = 1 - B*(0, 1 or 2), for Dose = None, Moderate or High, with five submodels given by B = 0.1, 0.2, ... 0.5, to cover weak oil effects (B = 0.1) to strong effects (B = 0.5). In the same way (but harder, I think) the models describing the Count parameters over space and time would also need to be either not too numerous or not too horribly complicated.

Appendix B - Agenda

SEAMAP/Deepwater Horizon Fishery Independent Data Collection Workshop

September 21 – 23, 2010 8 a.m. – 5 p.m.

September 24, 2010 8 a.m. – 12 p.m.

St. Petersburg Hilton

333 1st Street

St. Petersburg, Florida

Tuesday, September 21, 2010 – SEAMAP Fishery Independent Data Collection Workshop

1. Welcome and Introductions – Jeff Rester, Gulf States Marine Fisheries Commission; SEFSC Staff (Bonnie Ponwith or Todd Gedamke)

2. Goals of the Workshop – Jeff Rester

3. Brief Overview of Existing Fishery Independent Sampling Programs in the Gulf of Mexico – Jeff Rester

4. Data Needs for Stock Assessments in the Gulf of Mexico – NMFS

5. Potential Gears Used in Fishery Independent Sampling – Jeff Rester
    - Capture method (hook and line, traps, trawls, plankton nets)
    - Observational (camera, diver)
    - Habitat assessment (side scan, multibeam)

6. Fishery Independent Data Needs for the Gulf of Mexico – Break Out Group
    - Goals of this group will be to determine what types of data we need for management purposes and current data gaps
    - Also compile life history information of managed and important species (a discussion of species' life histories with considerations pertinent to life history data and designed surveys targeting specific life stages i.e. where do larval red snapper occur and when – Life history tables for managed species will be developed and distributed before the meeting) age, fecundity, growth, movement (tagging, microchem), diet

7. Statistical and Survey Design of Fishery Independent Surveys – Break Out Group
    - Goals of this group will be to design fishery independent surveys that provide a reliable method of calculating abundance for managed species that can also be used in ecosystem analysis as well as dealing with perturbations such as oil spills, liquefied natural gas facilities, red tides, etc.
    - Spatial
    - Temporal
    - Effort

Wednesday, September 22, 2010

6. Fishery Independent Data Needs for the Gulf of Mexico – Break Out Group
    - continued
7. Statistical and Survey Design of Fishery Independent Surveys – Break Out Group
    - continued
8. Costs Associated with Developed Surveys – All
    - Number of sea days needed for sampling
    - Type and number of vessels
    - Standardization process
    - How much sampling gear is needed
    - Will pilot studies be necessary to develop sampling protocols?
    - Researchers needed to conduct surveys
    - Number of sea days needed for sampling
    - Processing of samples after surveys (otoliths, gut contents, etc.)
    - Data management needs and costs

9. SEAMAP Meeting Wrap Up – Jeff Rester

Thursday, September 23, 2010 – Deepwater Horizon Fishery Data Collection and Impact Analyses

1. Welcome and Introductions – Todd Gedamke and Steven Brown

2. Overview and Goals of Workshop
    - Overview of the Deepwater Horizon Event
    - Natural Resource Damage Assessment Overview
    - Impact Assessment Needs

- Report from Workshop Planning Committee

3. Break Out Group Description (Tentative):

    - Survey Design and Statistics
        - Critically review strawmen (e.g. further stratification of existing design and addition of rotating panel approach) and baseline data
        - Suggest innovative survey design, data analysis and modeling
        - Identify key covariates and/or additional data needs
    - Survey Development Research/Advanced Technology
        - Identify and prioritize research needed to advance existing surveys (advanced technology, habitat, and process studies).
        - Identify topics for pilot-project scale work that can help inform surveys and data analyses
        - Provide guidance on the synthesis of additional data sources
    - Fostering Partnerships
        - Identify mechanisms for greater partnerships between state, federal, academic, industry, and stakeholders (e.g., routine monitoring, outreach, research, IOOS development)
        - Discuss development of comprehensive database, data management and data sharing mechanisms
    - Ecosystem Management/Marine Spatial Planning
        - Develop overview of potential data layers (e.g. physical, chemical, geological, biological, human-use) and make recommendations for data needs and integration
        - Develop list of major risks to the Gulf of Mexico ecosystem and services provided (i.e., hypoxia, warming, ocean acidification, hurricane damage to infrastructure and potential impacts, invasive species, land use patterns, fresh water management, etc)

4. Break Out Group Discussions and Writing

<u>Friday, September 24, 2010</u>

4. Break Out Group Discussions and Writing

    - continued

5. Break Out Group Reporting

6. Adjourn

Deepwater Horizon – SEAMAP Meeting – Working Groups

Working Groups for Thursday and Friday are listed below, along with the base level objectives. Note that Working Group objectives will be adjusted to some extent based on the discussions that occur on Tuesday and Wednesday.

Survey Design and Statistics

Lead: Jim Berkson; Rapporteurs: Kristin Erickson and Amy Tillman

- Critically review strawmen (e.g. further stratification of existing design and addition of rotating panel approach) and baseline data
- Suggest innovative survey design, data analysis and modeling
- Identify key covariates and/or additional data needs

Survey Development Research/Advanced Technology

Lead: Charles Thompson and Gary Fitzhugh; Rapporteur: TBD

- Identify and prioritize research needed to advance existing surveys (advanced technology, habitat, and process studies).
- Identify topics for pilot-project scale work that can help inform surveys and data analyses
- Provide guidance on the synthesis of additional data sources

Fostering Partnerships

Lead: James Nance; Rapporteur: Jim Ditty

- Identify mechanisms for greater partnerships between state, federal, academic, industry, and stakeholders (e.g., routine monitoring, outreach, research, IOOS development)
- Discuss development of comprehensive database, data management and data sharing mechanisms

Ecosystem Management/Marine Spatial Planning

Lead: Jerry Ault; Rapporteur: Paula Moreno

- Develop overview of potential data layers (e.g. physical, chemical, geological, biological, human-use) and make recommendations for data needs and integration

- Develop list of major risks to the Gulf of Mexico ecosystem and services provided (i.e., hypoxia, warming, ocean acidification, hurricane damage to infrastructure and potential impacts, invasive species, land use patterns, fresh water management, etc).

STATEMENT OF STATEGY FOR MEETING

This meeting is viewed by the organizers as the first in a series of steps that may move us toward a more integrated approach for living resource management in the Gulf of Mexico. It is NOT intended to produce a consensus opinion on the way forward. Rather it is intended to collect ideas and information from participants and to begin to build linkages between stakeholders.

Overall, there are four primary areas targeted for this workshop.

- The first is a review of the existing surveys. Are they appropriate and how can they be adjusted to provide better information while maintaining the utility of historical data? Concerns in this area are:
    - The ability of the surveys to provide high quality information for stock assessments regardless of conditions (hurricanes, climate shifts, oils spills, etc.).
    - The capacity of our survey data to provide background information and assess event-driven (e.g., Deepwater Horizon) changes for the Natural Resource Damage Assessment.
    - If we were to ramp up survey effort in the short term, how do we do it such that we can learn enough about the system to ramp back down in an intelligent manner? How do we stratify on the correct things?
- The second area is the development of 'next generation' survey and resource assessment methods. Current survey methods in the Gulf of Mexico are largely stratified on statistical reporting zones (shrimp grids) and somewhat on depth. The Gulf, however, has a diverse array of habitats (both seafloor AND water column) that may not be fully captured by the current stratification scheme. Also, there have been significant advances in technology (passive and active acoustics, AUVs, LIDAR, integrated ocean observing systems, optics, video, sea floor mapping, genetics, satellite sensors, modeling, etc.) that could significantly improve our ability to monitor the system at the right scales. Which technologies are most appropriate and how do we move toward routine deployment? How do we make our survey and monitoring programs better and more cost effective?
- Third, there is a need for increased partnership and collaborative data collection, sharing and analysis. The Deepwater Horizon Incident demonstrated that effective response, damage assessment, and mitigation require working across the boundaries between all stakeholders – including government, academic, ngos, and industry. Enhanced collaboration will lead to more

competent and cost-effective monitoring and response programs and better science for resource management.

- The fourth area Integrated Ecosystem Assessment and Marine Spatial Planning. These are NOAA programmatic initiative areas and are highly relevant for the Gulf of Mexico. The Gulf possesses a significant amount of industrial infrastructure both at sea and along the coastline. It also has incredible habitat and species diversity, as well as high risks for extreme weather events. Moreover, because it is an enclosed ocean basin in an area that is forced by interplay between El Nino and Atlantic Warm Pool dynamics, it is particularly vulnerable to climate-scale variability – northerly range expansion is not possible. There is a need to assess the risks, identify the various services stakeholder wish to derive from the Gulf, and move toward a recursive management strategy that will the tools described above to intelligently manage the unavoidable increase in development in the coastal zone.

We hope that you'll consider these areas during the course of the meeting and will share your thoughts and concerns.

Appendix C - Overview of Existing Surveys

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

BOTTOM LONGLINE SURVEYS

NOAA Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories,
Resource Surveys Branch

Prepared by: Terry Henwood, Paula Moreno, Walter Ingram, Mark Grace

NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

CONTENTS

NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

Bottom Longline Surveys

Mainline Net Reel

Retrieving Longline

High Fliers (Deployed on ends)

Gear:

- A hydraulic longline reel is used for setting and retrieving the mainline. Radar reflecting buoys are used to mark longline locations.
- Bottom longline gear components include 1.0 nautical mile (nm) of 426 kg (1000 lb) test monofilament mainline, #15/0 circle hooks baited with Atlantic mackerel (*Scomber scombrus*), 3.66 m (12 ft) gangions (leaders) of 332 kg (730 lb) test monofilament.
- Longline gear (100 hooks) is fished for 1 hr (determined as the duration between deployment of the last longline set buoy to retrieval of the first buoy to begin haulback).
- Catch per unit effort (CPUE) is defined as catch/100 hook hr.

Years Conducted:

- 1995-2010

Depth Range:

- 9.14 –365.76 m (5 – 200 fathoms)

Survey Design:

- Longline stations are proportionally allocated based upon total available area within each 60 nm sampling zone (shrimp statistical zones). Fifty percent of the effort within each zone is allocated to the 9 –55 m (5 - 30 fm) depth strata, 40% is allocated to the 55–183 m (31 - 100 fm) depth strata and 10% is allocated between 183–366 m (100 – 200 fm).
- Stratification is by shrimp statistical zones and depth strata.

CV and Index Plots for Species with Highest Catch Rates from the Bottom Longline Survey

For each species, the smaller graph is of annual relative abundance indices (with 95% confidence intervals) with relative abundance on the vertical axis and survey year on the horizontal axis. The larger graph consists of two plots with CV (coefficient of variation of the mean index value) on the vertical axis and sample size on the horizontal axis. The continuous line represents a theoretical CV by sample size, which is based on the points therein. The points represent actual CV values and survey sample sizes.

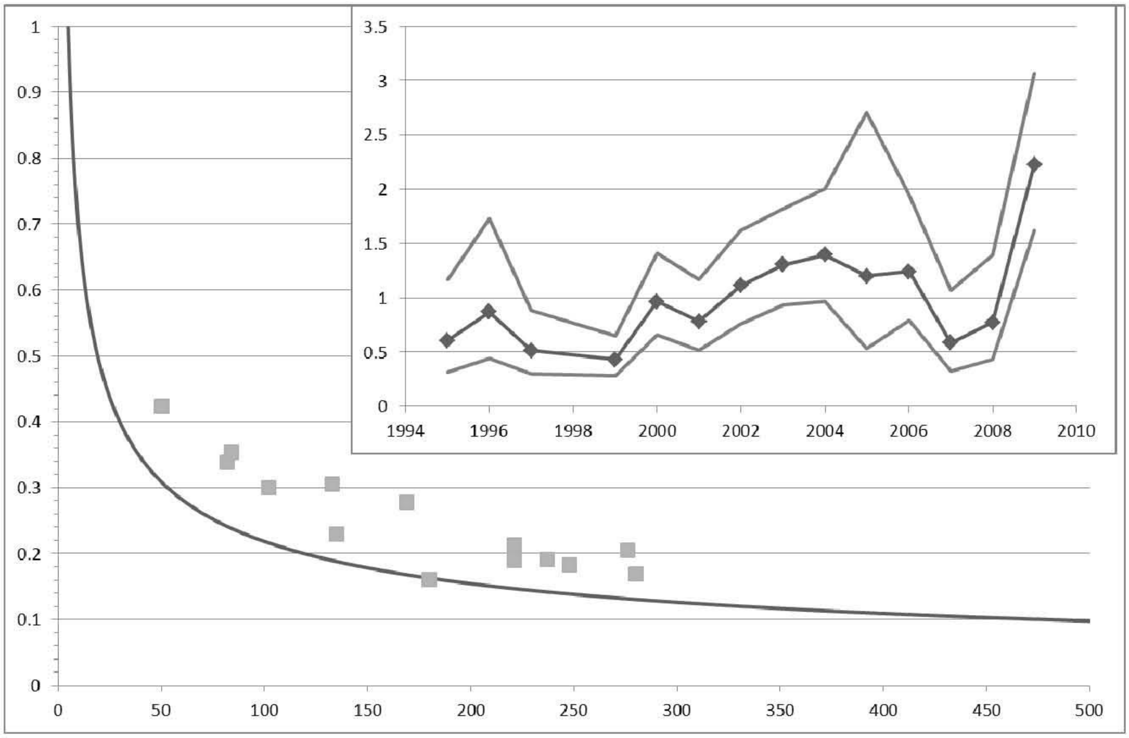
Top 20 species sorted by catch rate (number per 100 hooks per hour) collected during the NMFS Bottom Longline Survey 1995-2009.

Rank	Taxon	Common Name	Catch Rate
1	*Rhizoprionodon terraenovae*	Atlantic sharpnose shark	4.30310
2	*Carcharhinus acronotus*	Blacknose shark	0.74920
3	*Carcharhinus limbatus*	Blacktip shark	0.56044
4	*Mustelus canis*	Smooth dogfish	0.51287
5	*Ophichthus rex*	King snake eel	0.43382
6	*Carcharhinus brevipinna*	Spinner shark	0.32374
7	*Epinephelus morio*	Red grouper	0.28230
8	*Lutjanus campechanus*	Red snapper	0.24307
9	*Carcharhinus plumbeus*	Sandbar shark	0.17398
10	*Epinephelus flavolimbatus*	Yellowedge grouper	0.14396
11	*Lopholatilus chamaeleonticeps*	Tilefish	0.13007
12	*Bagre marinus*	Gafftopsail catfish	0.12839
13	*Sphyrna lewini*	Scalloped hammerhead	0.10276
14	*Galeocerdo cuvieri*	Tiger shark	0.09590
15	*Ginglymostoma cirratum*	Nurse shark	0.08709
16	*Carcharhinus leucas*	Bull shark	0.07800
17	*Centrophorus granulosus*	Gulper shark	0.06289
18	*Carcharhinus falciformis*	Silky shark	0.05681
19	*Mustelus sinusmexicanus*	Gulf smooth-hound	0.04942
20	*Sphyraena barracuda*	Great barracuda	0.04448

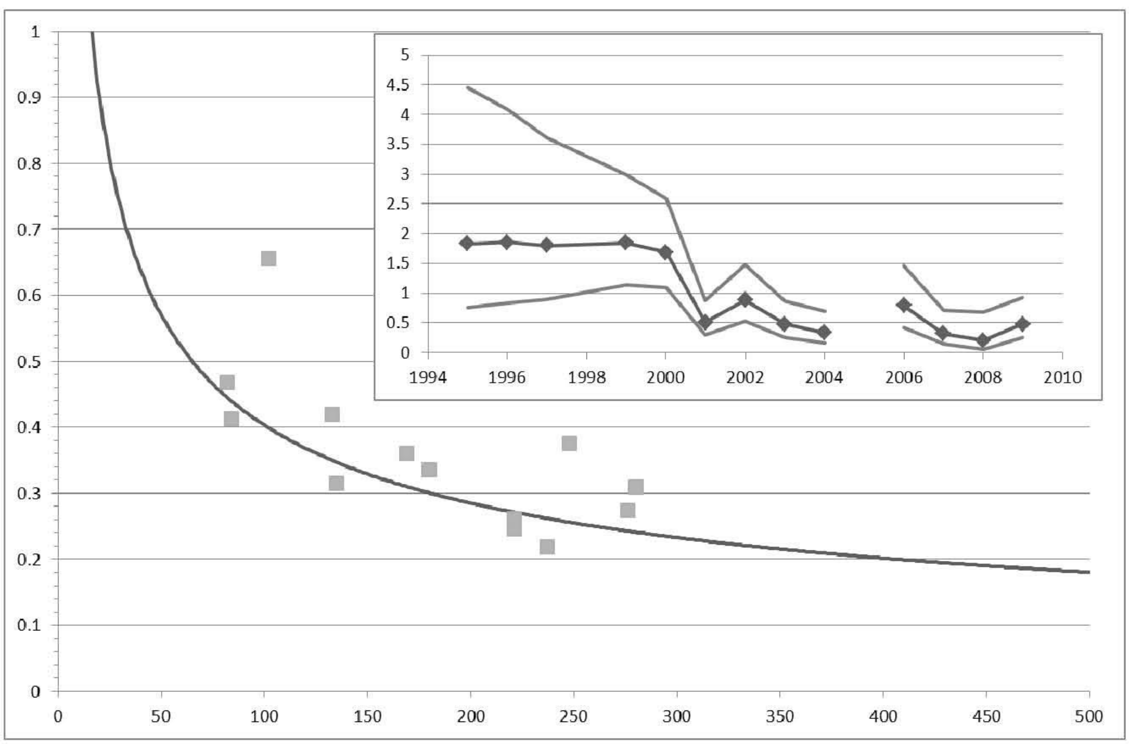
Top 20 species sorted by frequency of occurrence during the NMFS Bottom Longline Survey 1995-2009.

Rank	Taxon	Common Name	Frequency
1	*Rhizoprionodon terraenovae*	Atlantic sharpnose shark	0.42952
2	*Carcharhinus acronotus*	Blacknose shark	0.24225
3	*Carcharhinus limbatus*	Blacktip shark	0.17321
4	*Ophichthus rex*	King snake eel	0.13229
5	*Mustelus canis*	Smooth dogfish	0.11658
6	*Carcharhinus plumbeus*	Sandbar shark	0.10790
7	*Lutjanus campechanus*	Red snapper	0.09425
8	*Carcharhinus brevipinna*	Spinner shark	0.08433
9	*Sphyrna lewini*	Scalloped hammerhead	0.08185
10	*Epinephelus morio*	Red grouper	0.07813
11	*Galeocerdo cuvieri*	Tiger shark	0.07606
12	*Epinephelus flavolimbatus*	Yellowedge grouper	0.06738
13	*Ginglymostoma cirratum*	Nurse shark	0.05250
14	*Carcharhinus falciformis*	Silky shark	0.04713
15	*Carcharhinus leucas*	Bull shark	0.04423
16	*Lopholatilus chamaeleonticeps*	Tilefish	0.04010
17	*Sphyraena barracuda*	Great barracuda	0.03390
18	*Bagre marinus*	Gafftopsail catfish	0.02811
19	*Sphyrna mokarran*	Great hammerhead	0.01778
20	*Arius felis*	Hardhead catfish	0.01612

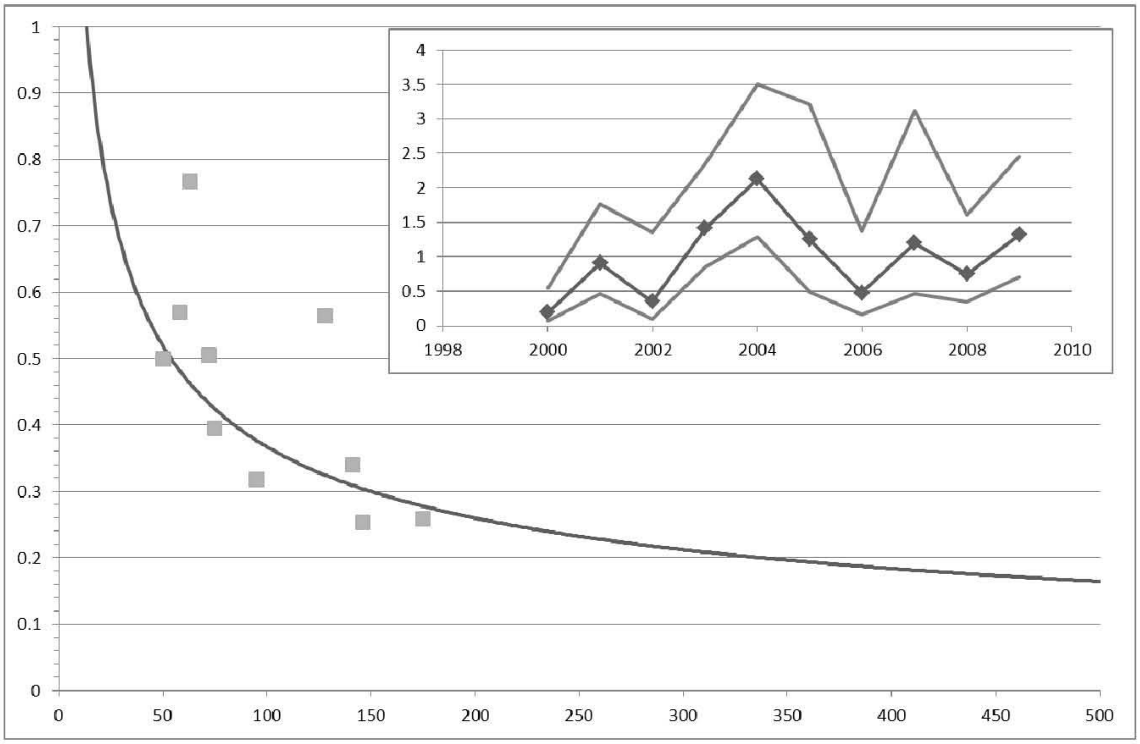
CV PLOTS



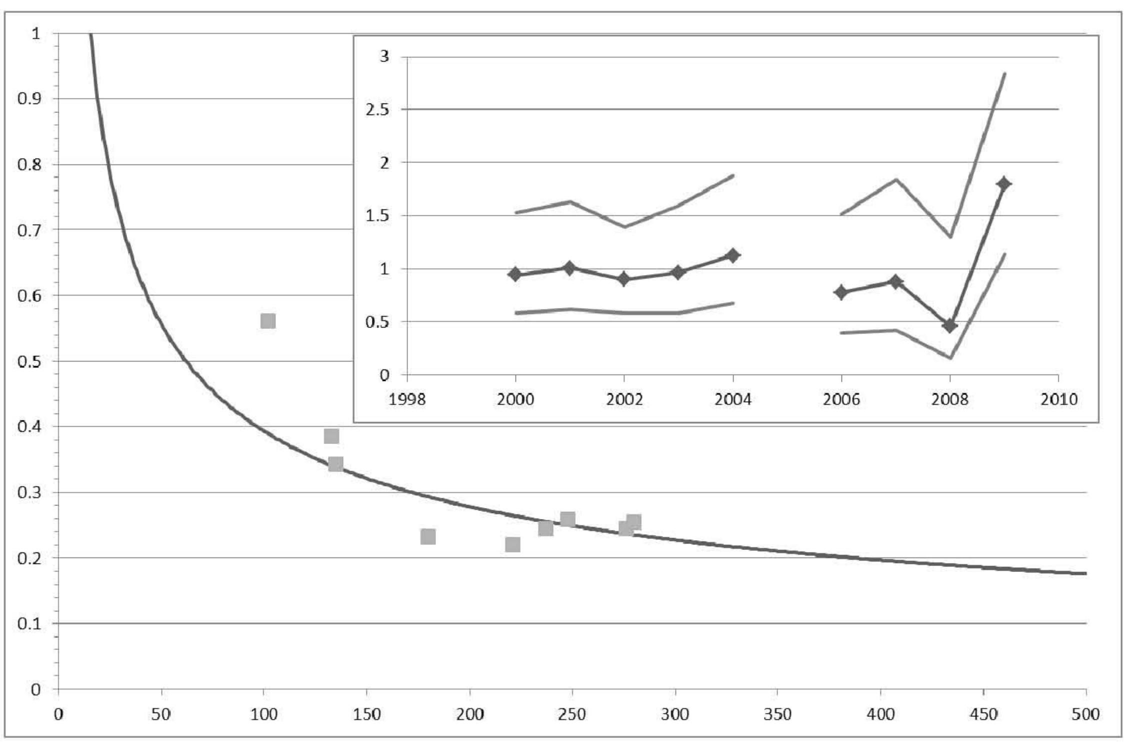
RHIZOPRIONODON_TERRAENOVAE



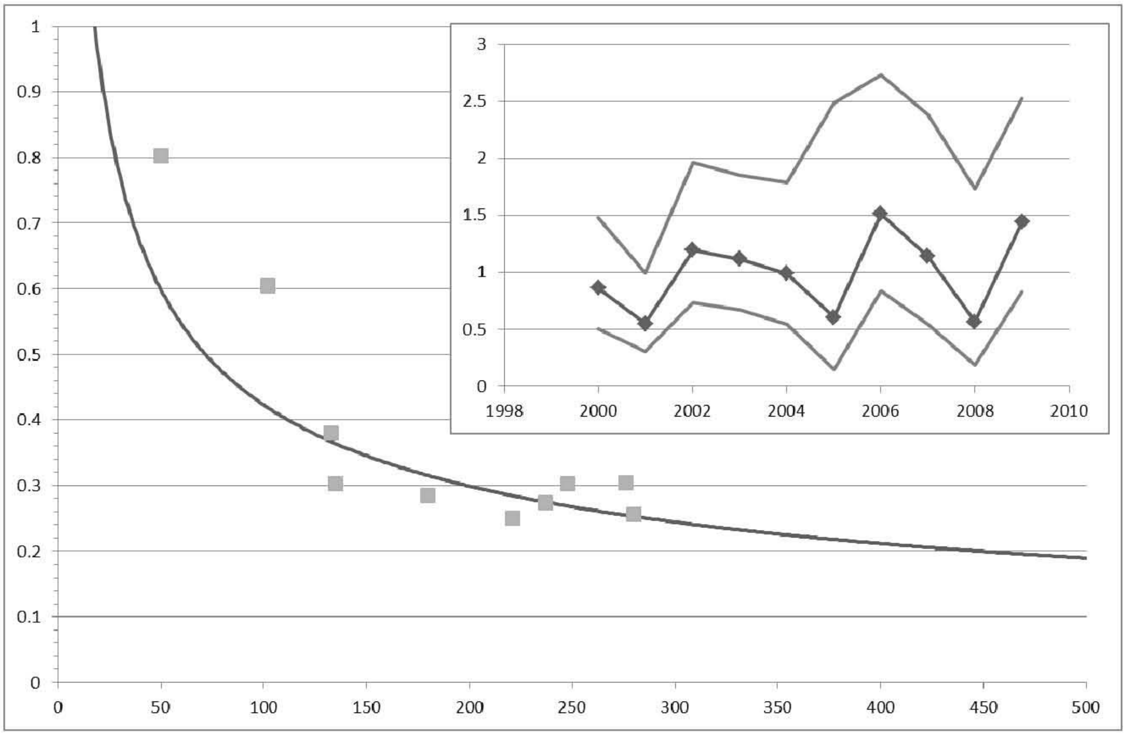
OPHICHTHUS_REX



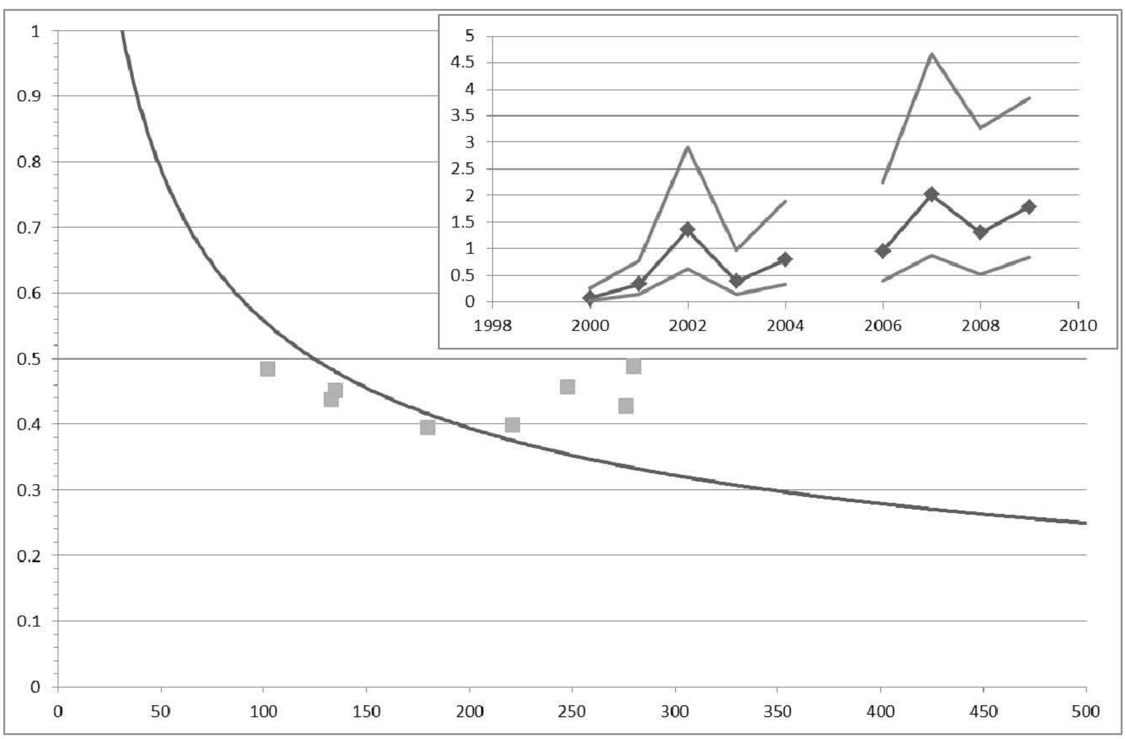
EPINEPHELUS_MORIO



LUTJANUS_CAMPECHANUS



EPINEPHELUS_FLAVOLIMBATUS

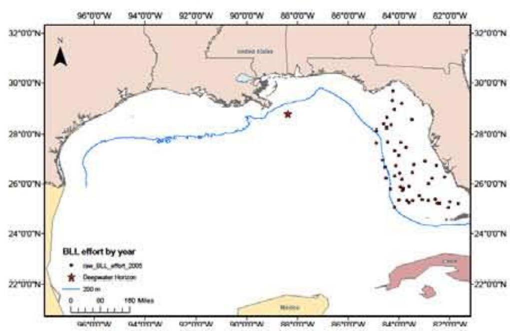


LOPHOLATILUS_CHAMAELEON

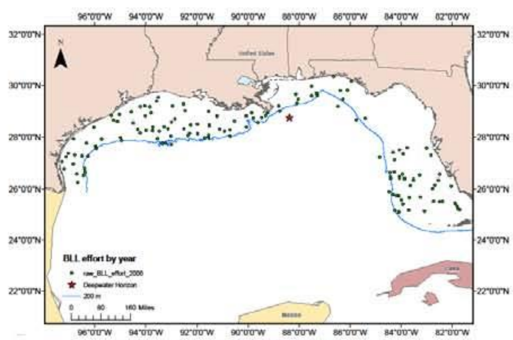
BOTTOM LONGLINE SURVEY EFFORT

By Year:

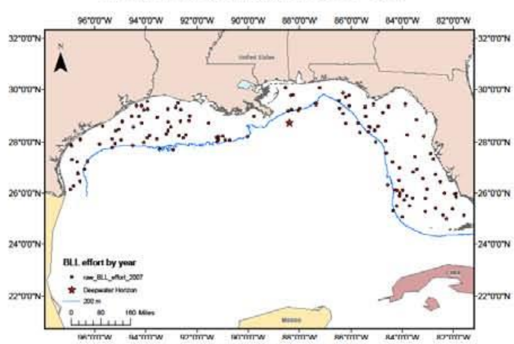
SEAMAP BOTTOM LONGLINE SURVEYS - 2005



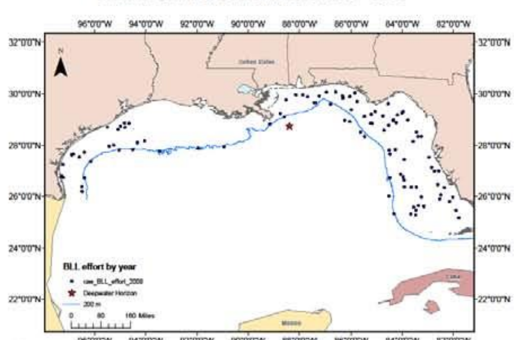
SEAMAP BOTTOM LONGLINE SURVEYS - 2006



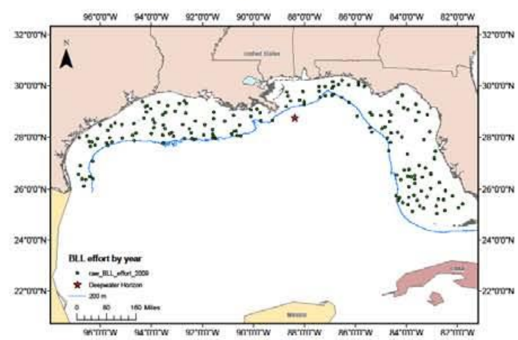
SEAMAP BOTTOM LONGLINE SURVEYS - 2007



SEAMAP BOTTOM LONGLINE SURVEYS - 2008

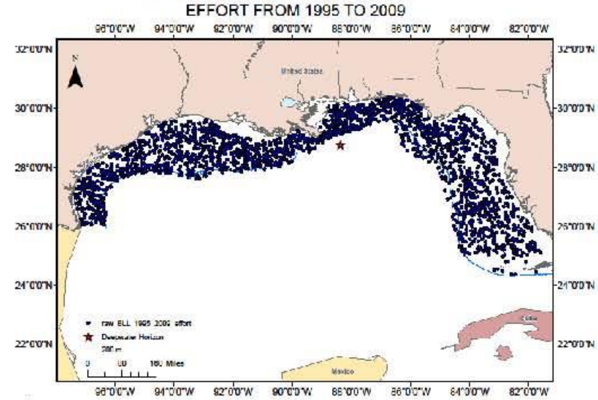


SEAMAP BOTTOM LONGLINE SURVEYS - 2009



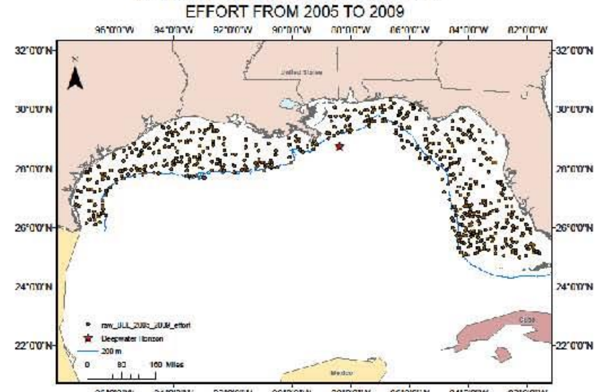
Combined effort from 1995 to 2009:

SEAMAP BOTTOM LONGLINE SURVEYS -
EFFORT FROM 1995 TO 2009



Combined effort from 2005 to 2009:

SEAMAP BOTTOM LONGLINE SURVEYS -
EFFORT FROM 2005 TO 2009

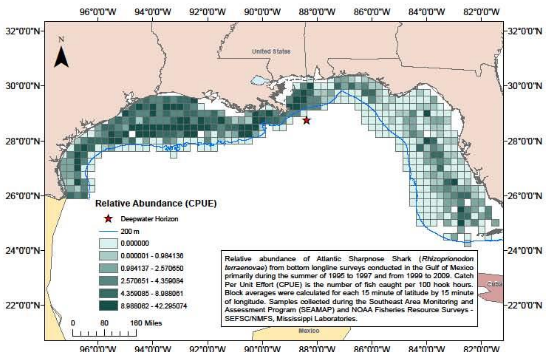


NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

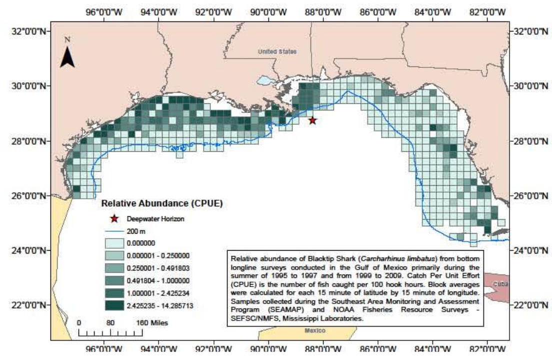
Prepared by: Paula Moreno
9/14/2010, Version 1

BOTTOM LONGLINE DOMINANT SPECIES (Sharks)

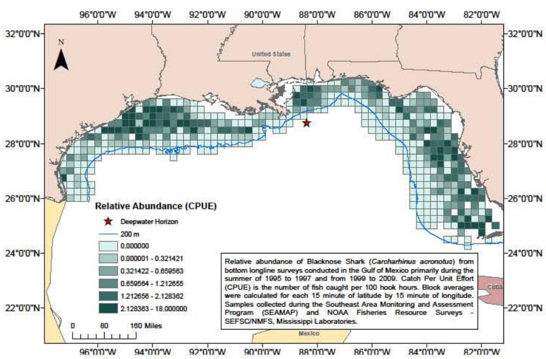
SEAMAP BOTTOM LONGLINE SURVEYS - ATLANTIC SHARPNOSE SHARK



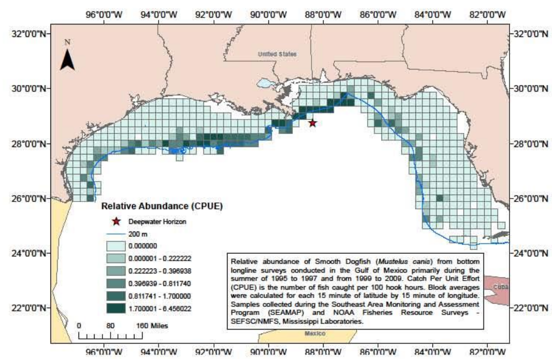
SEAMAP BOTTOM LONGLINE SURVEYS - BLACKTIP SHARK



SEAMAP BOTTOM LONGLINE SURVEYS - BLACKNOSE SHARK



SEAMAP BOTTOM LONGLINE SURVEYS - SMOOTH DOGFISH



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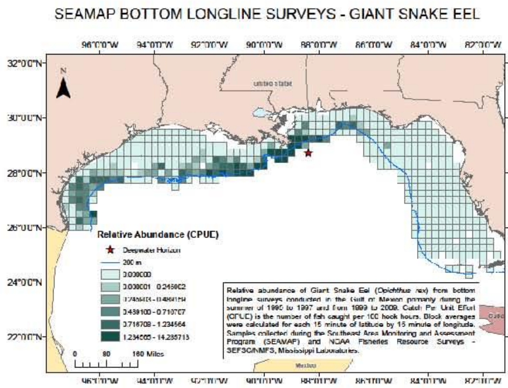
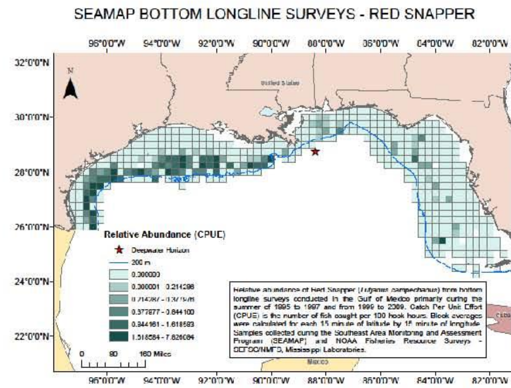
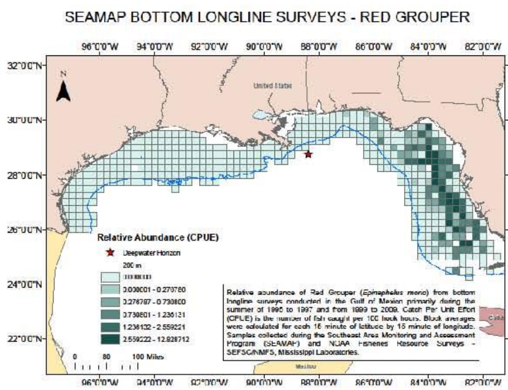
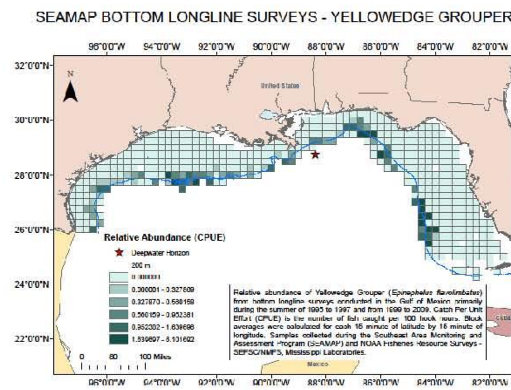
BOTTOM LONGLINE DOMINANT SPECIES (Bony fishes)









NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

Prepared by: Paula Moreno
9/14/2010, Version 1

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

SHRIMP/GROUNDFISH SURVEYS

NOAA Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories, Resource Surveys Branch

Prepared by: Terry Henwood, Paula Moreno, Walter Ingram, Gilmore Pellegrin Jr.

NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

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Southeast Fisheries Science Center
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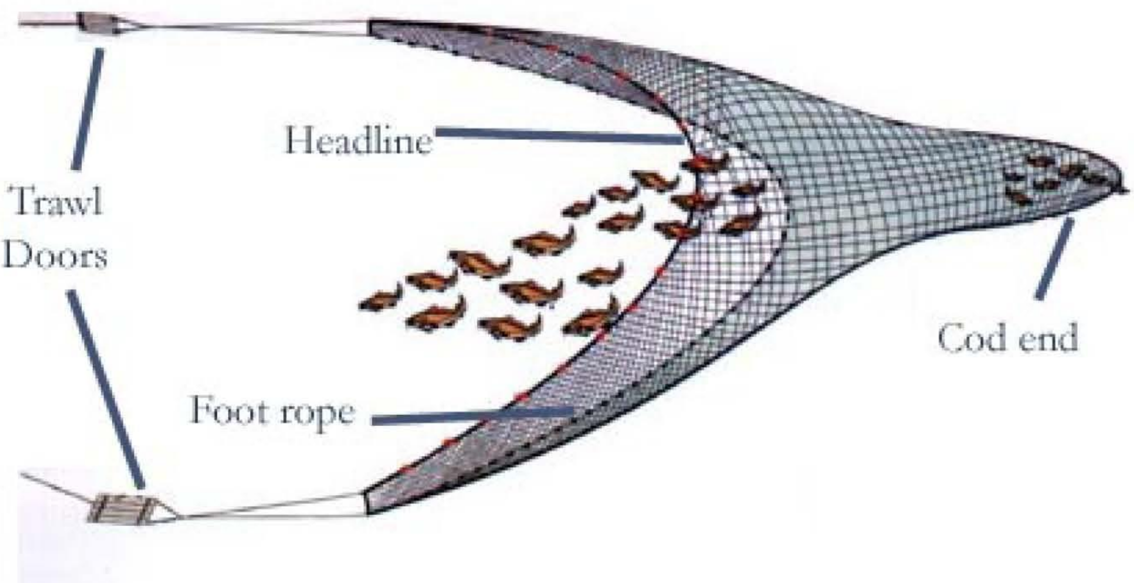
Shrimp/Groundfish Trawl Surveys

Shrimp/groundfish trawling gear



Tail bag

Gear:

- The standard gear used on these surveys is a 40-ft otter trawl towed as a speed of 2.0-2.5 kts.

Years Conducted:

Summer SEAMAP Shrimp/Groundfish Survey

- 1982 - Conducted to assess the impact of the Texas Closure shrimp management technique initiated in 1981.
- 1987 - Adopted the SEAMAP sampling protocol with the following objectives:
    - Provide indices of relative abundance for species occurring in 5-60 fathoms off the coasts of Texas, Louisiana, Mississippi and Alabama.
    - Provide indices of relative abundance for commercial shrimp species off the Texas coast.
    - Collect size, sex, maturation and life history data of sampled species.
    - Provide data from the hypoxic zone occurring in the northern GOM.
    - Collect ichthyoplankton data.

Fall SEAMAP Shrimp/Groundfish Survey

- Mid-1950s to 1972 – Surveys were "exploratory", not the result of a formal statistical design.
- 1972 – Resource assessment survey was initiated in response to concerns over declining catch rates of industrial bottomfish. Fall season was selected since this was the season of major offshore abundance (although some Winter, Spring and Summer sampling was conducted).
- 1985 to 1986 – Sampling intensity was decreased and geographic coverage was increased.
- 1987 – Adopted the SEAMAP sampling protocol.

Depth Range:

- 9.14 –109.73 m (5 – 60 fathoms)

Survey Design:

- Stratified random station location assignment with strata derived from:
    - Depth zones (5-6, 6-7, 7-8, 8-9, 9-10, 10-11, 11-12, 12-13, 13-14, 14-15, 15-16, 16-17, 17-18, 18-19, 19-20, 20-22, 22-25, 25-30, 30-35, 35-40, 40-45, 45-50 and 50-60 fathoms)
    - Shrimp statistical zones (between 88° and 97° W longitude, statistical zones from west to east: 21-20, 19-18, 17-16, 15-13 and 12-10)
    - Time of day (i.e. day or night).
- During a SEAMAP sampling station, trawls were fished perpendicular to the depth strata and required to cover the entire stratum. This resulted in multiple tows (tows were limited to one hour) and long tow times in areas where the ocean floor had little change in depth over distance trawled.
- Trawling stations were proportionally allocated by area of bottom in various depth strata and assigned randomly between 5 and 60 fathoms in the same geographic region.

Recent changes in survey design:

- Trawling stations are not stratified by day and night.
    - Instead they are sampled consecutively regardless of time of day.
- Trawls are conducted for a maximum of 30 minutes per station.
- Trawling stations are proportionally allocated by area of bottom in various depth strata and assigned randomly between 5 and 60 fathoms in the same geographic region.
- Stratification is by shrimp statistical zone with proportional allocation of effort based on surface area within each zone.

CV and Index Plots for Species with Highest Catch Rates from the Summer and Fall Groundfish Trawl Surveys

For each species, the smaller graph is of annual relative abundance indices (with 95% confidence intervals) with relative abundance on the vertical axis and survey year on the horizontal axis. The larger graph consists of two plots with CV (coefficient of variation of the mean index value) on the vertical axis and sample size on the horizontal axis. The continuous line represents a theoretical CV by sample size, which is based on the points therein. The points represent actual CV values and survey sample sizes.

Top 20 species sorted by catch rate (number per trawl-hour) collected during the NMFS Summer Groundfish Trawl Survey 1987-2009.

Rank	Taxon	Common Name	Catch Rate
1	*Micropogonias undulatus*	Atlantic croaker	604.910
2	*Stenotomus caprinus*	Longspine porgy	407.800
3	*Farfantepenaeus aztecus*	Brown shrimp	254.082
4	*Peprilus burti*	Gulf butterfish	176.921
5	*Prionotus longispinosus*	Bigeye searobin	82.526
6	*Trachurus lathami*	Rough scad	72.160
7	*Trichiurus lepturus*	Atlantic cutlassfish	54.077
8	*Leiostomus xanthurus*	Spot	50.460
9	*Anchoa hepsetus*	Striped anchovy	49.465
10	*Cynoscion arenarius*	Sand seatrout	39.094
11	*Cynoscion nothus*	Silver seatrout	36.577
12	*Serranus atrobranchus*	Blackear bass	35.611
13	*Centropristis philadelphica*	Rock sea bass	34.461
14	*Sicyonia brevirostris*	Brown rock shrimp	33.930
15	*Upeneus parvus*	Dwarf goatfish	31.387
16	*Lagodon rhomboides*	Pinfish	19.969
17	*Farfantepenaeus duorarum*	Pink shrimp	19.011
18	*Synodus foetens*	Inshore lizardfish	18.664
19	*Etrumeus teres*	Round herring	14.820
20	*Litopenaeus setiferus*	White shrimp	10.933

Top 20 species sorted by frequency of occurrence during the NMFS Summer Groundfish Trawl Survey 1987-2009.

Rank	Taxon	Common Name	Frequency
1	*Farfantepenaeus aztecus*	Brown shrimp	0.75348
2	*Stenotomus caprinus*	Longspine porgy	0.68075
3	*Synodus foetens*	Inshore lizardfish	0.61796
4	*Peprilus burti*	Gulf butterfish	0.55517
5	*Centropristis philadelphica*	Rock sea bass	0.49934
6	*Micropogonias undulatus*	Atlantic croaker	0.45659
7	*Prionotus longispinosus*	Bigeye searobin	0.44218
8	*Upeneus parvus*	Dwarf goatfish	0.37657
9	*Lagodon rhomboides*	Pinfish	0.37243
10	*Trachurus lathami*	Rough scad	0.36382
11	*Cynoscion arenarius*	Sand seatrout	0.34791
12	*Lutjanus* sp.	Snappers	0.34327
13	*Trichiurus lepturus*	Atlantic cutlassfish	0.34129
14	*Lutjanus campechanus*	Red snapper	0.31146
15	*Serranus atrobranchus*	Blackear bass	0.30633
16	*Sicyonia brevirostris*	Brown rock shrimp	0.27783
17	*Pristipomoides aquilonaris*	Wenchman	0.26325
18	*Anchoa hepsetus*	Striped anchovy	0.25232
19	*Leiostomus xanthurus*	Spot	0.24917
20	*Cynoscion nothus*	Silver seatrout	0.23144

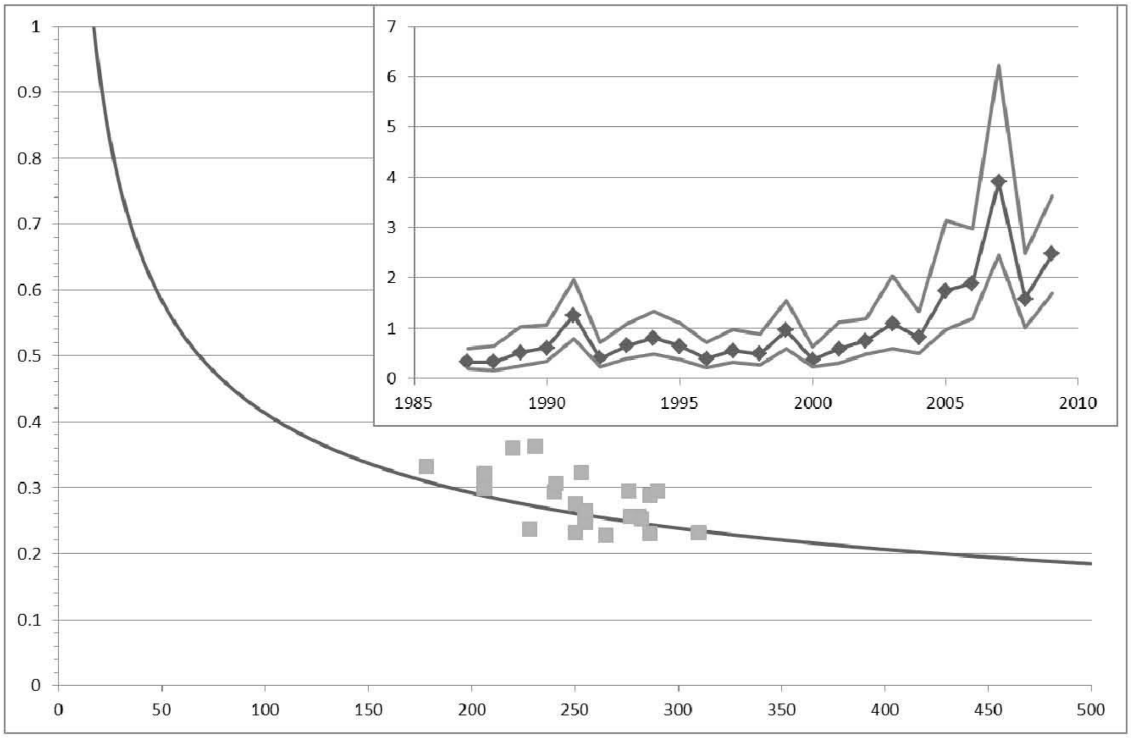
Top 20 species sorted by catch rate (number per trawl-hour) collected during the NMFS Fall Groundfish Trawl Survey 1987-2009.

Rank	*Taxon*	*Common Name*	*Catch Rate*
1	*Micropogonias undulatus*	Atlantic croaker	621.295
2	*Stenotomus caprinus*	Longspine porgy	185.046
3	*Farfantepenaeus aztecus*	Brown shrimp	86.826
4	*Leiostomus xanthurus*	Spot	65.302
5	*Trachurus lathami*	Rough scad	53.515
6	*Peprilus burti*	Gulf butterfish	46.385
7	*Arius felis*	Hardhead catfish	38.210
8	*Prionotus longispinosus*	Bigeye searobin	34.997
9	*Cynoscion nothus*	Silver seatrout	34.486
10	*Serranus atrobranchus*	Blackear bass	29.764
11	*Anchoa hepsetus*	Striped anchovy	27.438
12	*Litopenaeus setiferus*	White shrimp	26.767
13	*Trichiurus lepturus*	Atlantic cutlassfish	24.330
14	*Cynoscion arenarius*	Sand seatrout	24.172
15	*Lutjanus* sp.	Snappers	22.529
16	*Synodus foetens*	Inshore lizardfish	20.714
17	*Lagodon rhomboides*	Pinfish	18.500
18	*Lutjanus campechanus*	Red snapper	18.175
19	*Centropristis philadelphica*	Rock sea bass	16.509
20	*Upeneus parvus*	Dwarf goatfish	11.782

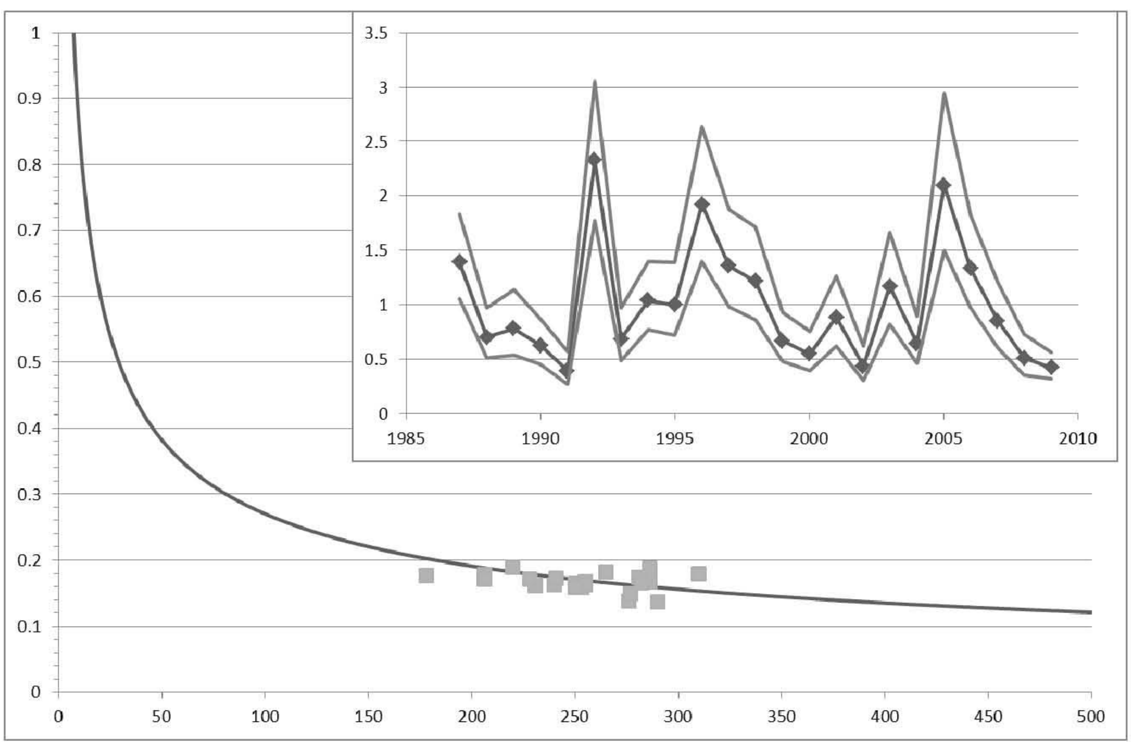
Top 20 species sorted by frequency of occurrence during the NMFS Fall Groundfish Trawl Survey 1987-2009.

Rank	*Taxon*	*Common Name*	*Frequency*
1	*Farfantepenaeus aztecus*	Brown shrimp	0.79447
2	*Micropogonias undulatus*	Atlantic croaker	0.78543
3	*Synodus foetens*	Inshore lizardfish	0.68767
4	*Stenotomus caprinus*	Longspine porgy	0.62110
5	*Lutjanus* sp.	Snappers	0.61367
6	*Lutjanus campechanus*	Red snapper	0.57457
7	*Centropristis philadelphica*	Rock sea bass	0.55986
8	*Leiostomus xanthurus*	Spot	0.54209
9	*Prionotus longispinosus*	Bigeye searobin	0.51543
10	*Cynoscion arenarius*	Sand seatrout	0.51511
11	*Peprilus burti*	Gulf butterfish	0.48231
12	*Lagodon rhomboides*	Pinfish	0.45710
13	*Cynoscion nothus*	Silver seatrout	0.44046
14	*Litopenaeus setiferus*	White shrimp	0.38213
15	*Trichiurus lepturus*	Atlantic cutlassfish	0.34238
16	*Lutjanus synagris*	Lane snapper	0.28890
17	*Arius felis*	Hardhead catfish	0.28114
18	*Trachurus lathami*	Rough scad	0.27694
19	*Serranus atrobranchus*	Blackear bass	0.27597
20	*Upeneus parvus*	Dwarf goatfish	0.26499

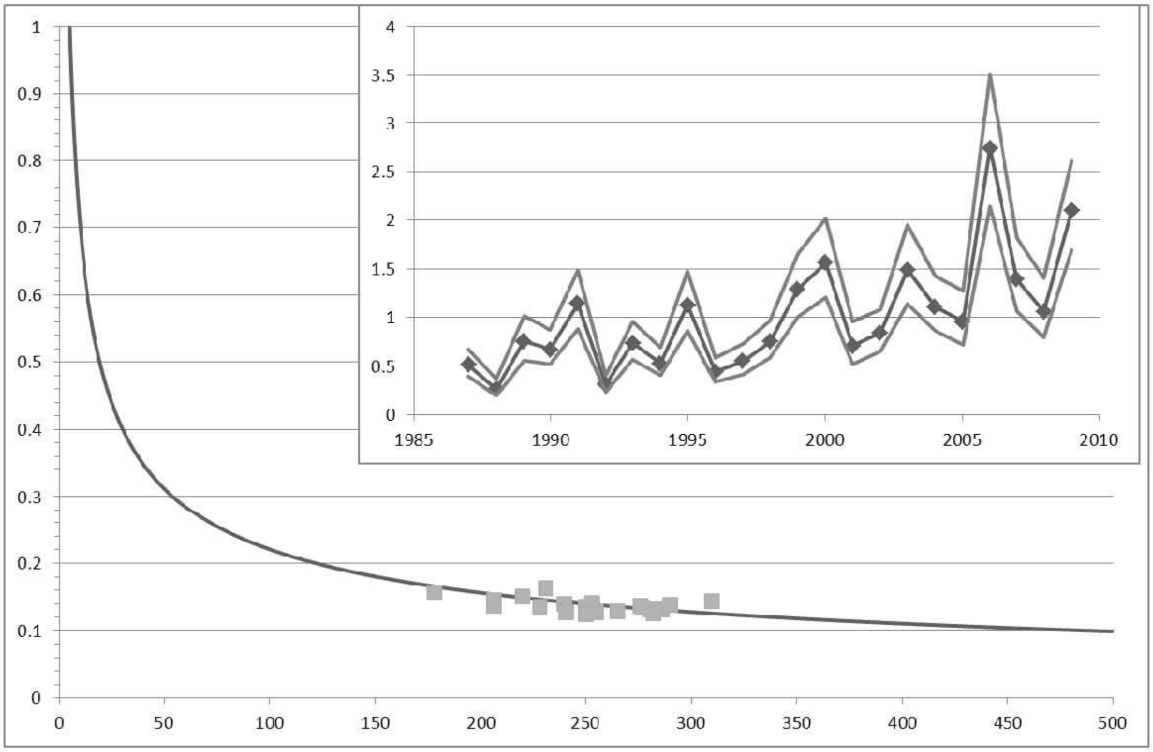
CV PLOTS - SUMMER



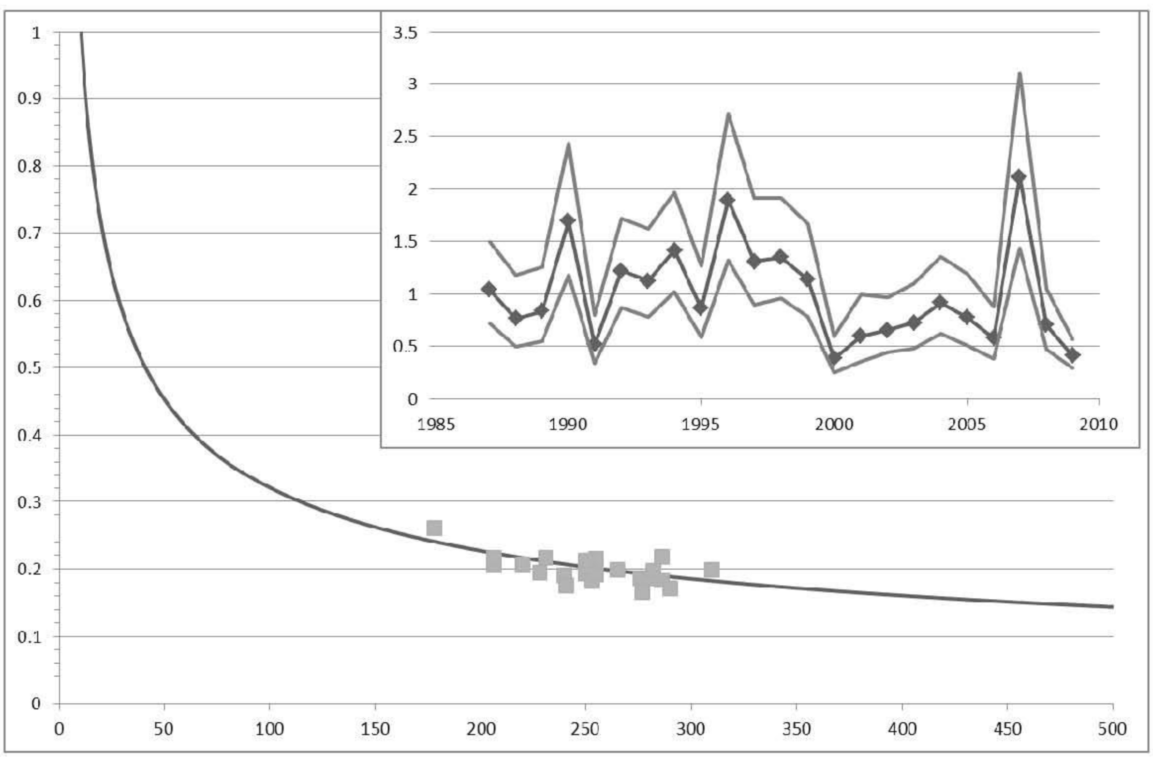
Atlantic Croaker



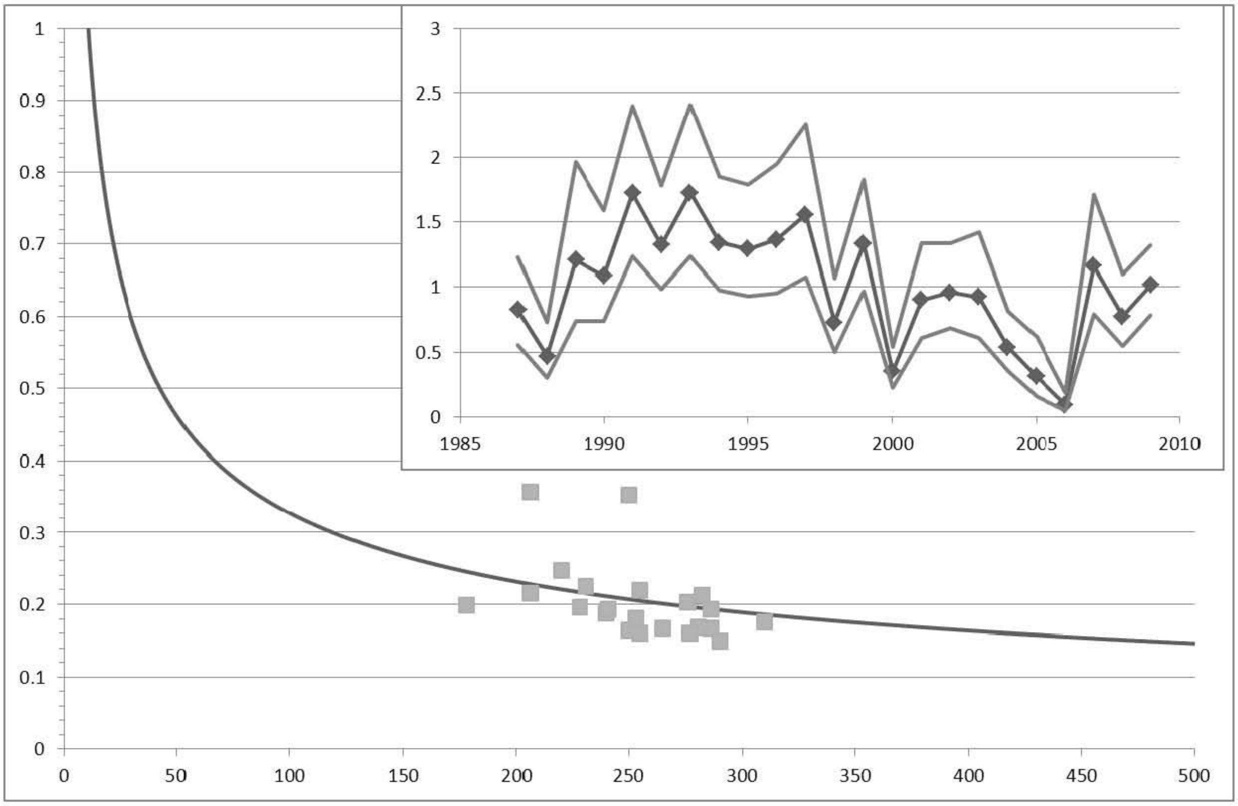
Longspine Porgy



Brown Shrimp

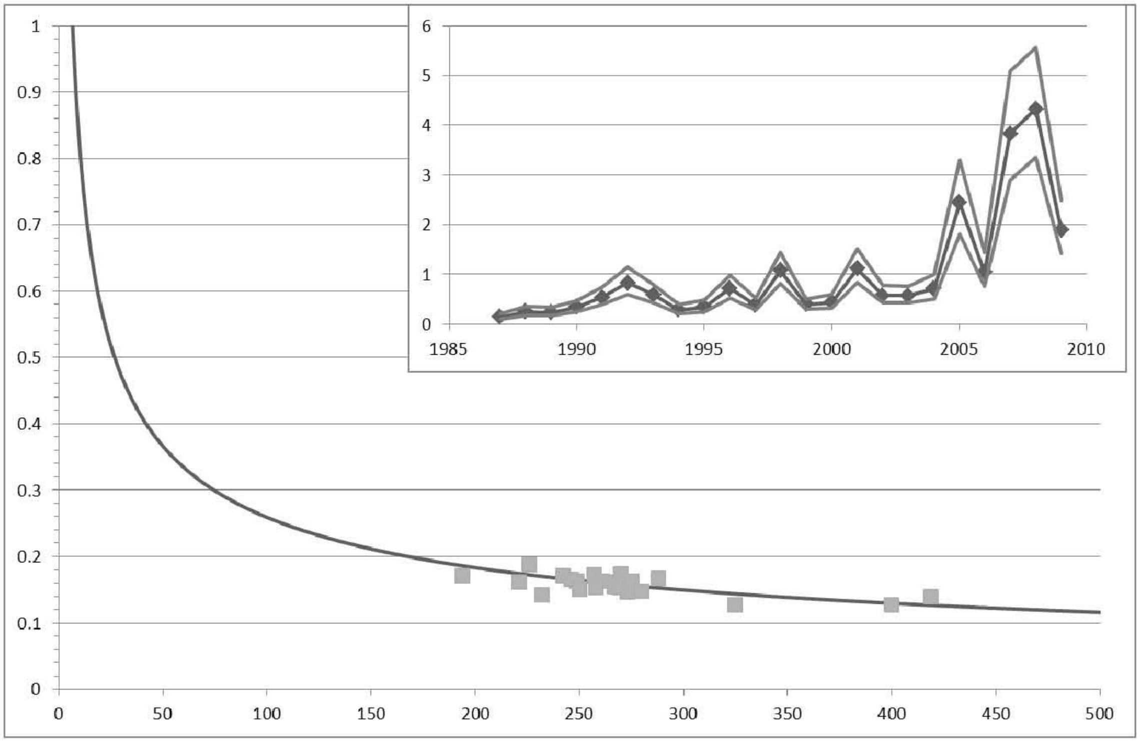


Gulf Butterfish

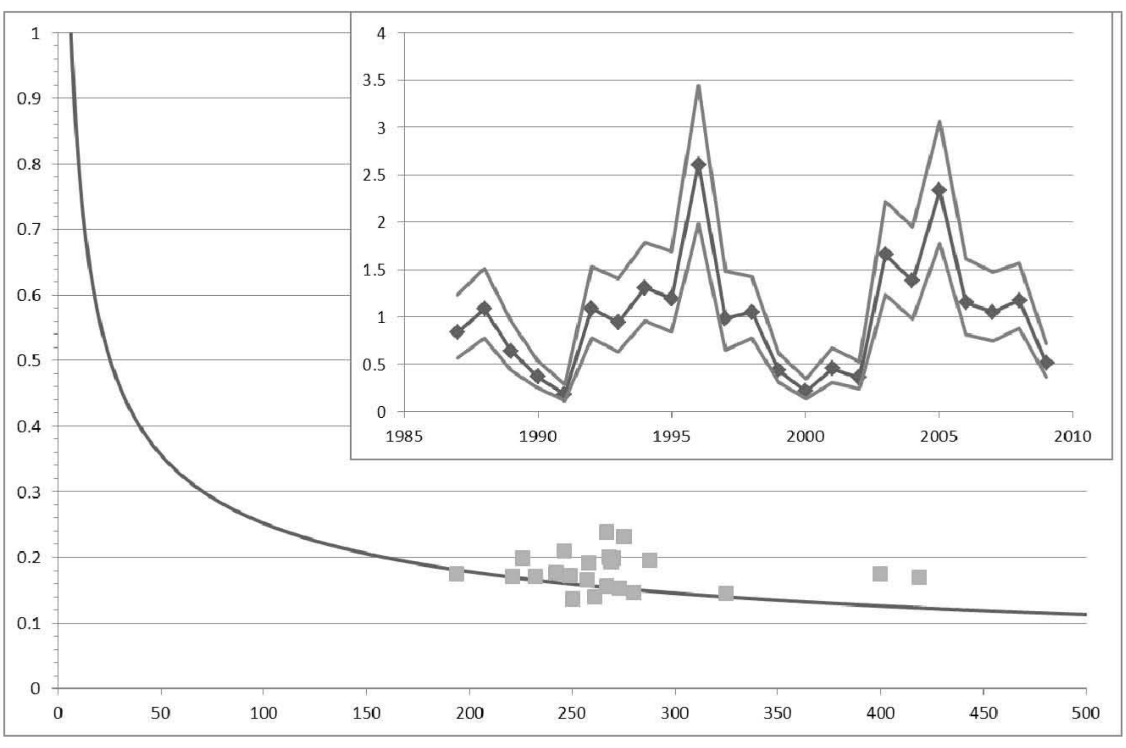


Prionotus longispinosus

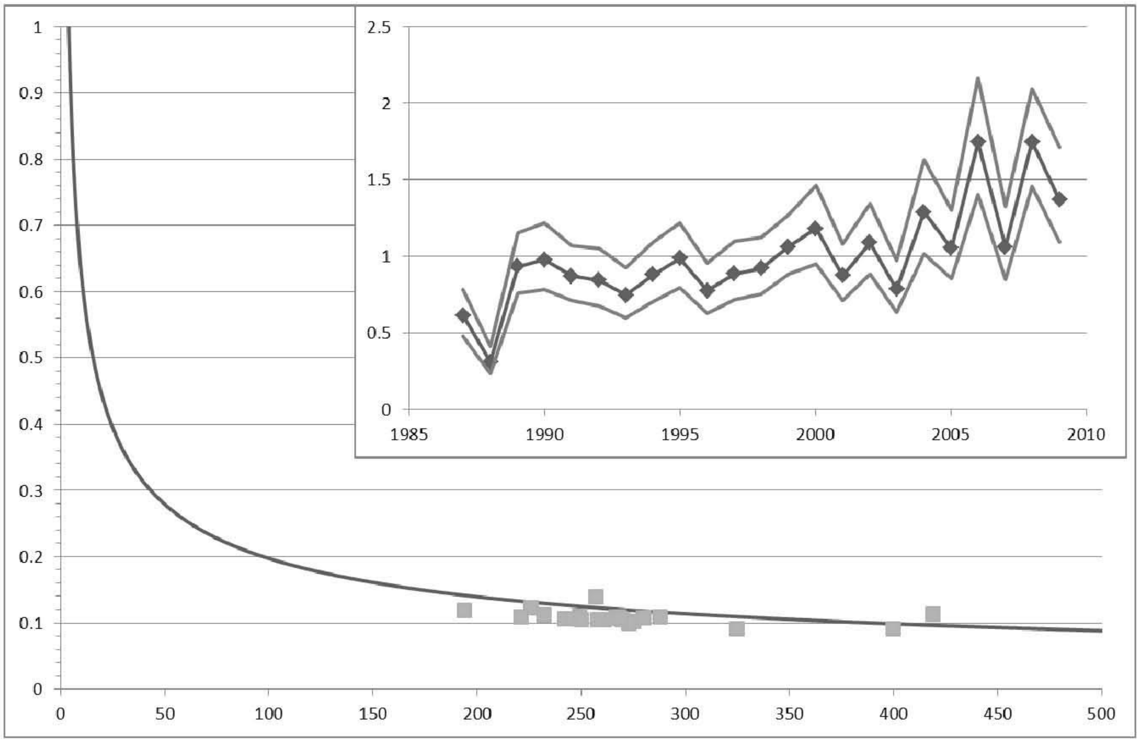
CV PLOTS - FALL



Atlantic Croaker



Longspine Porgy



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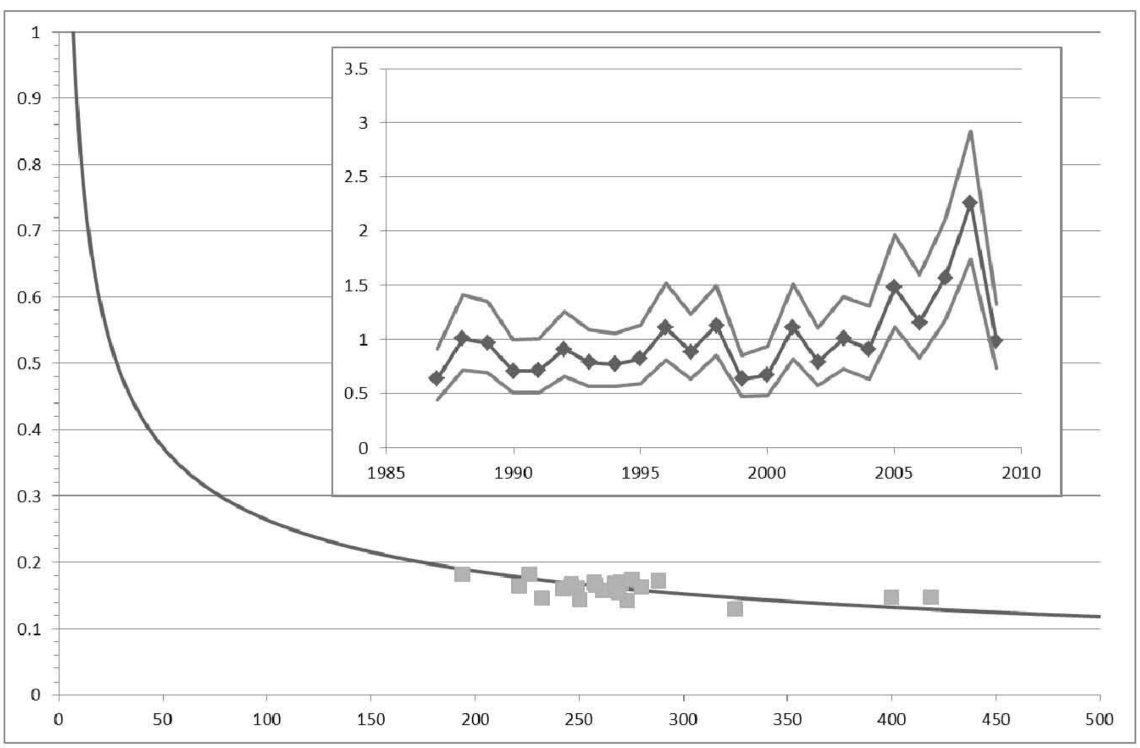
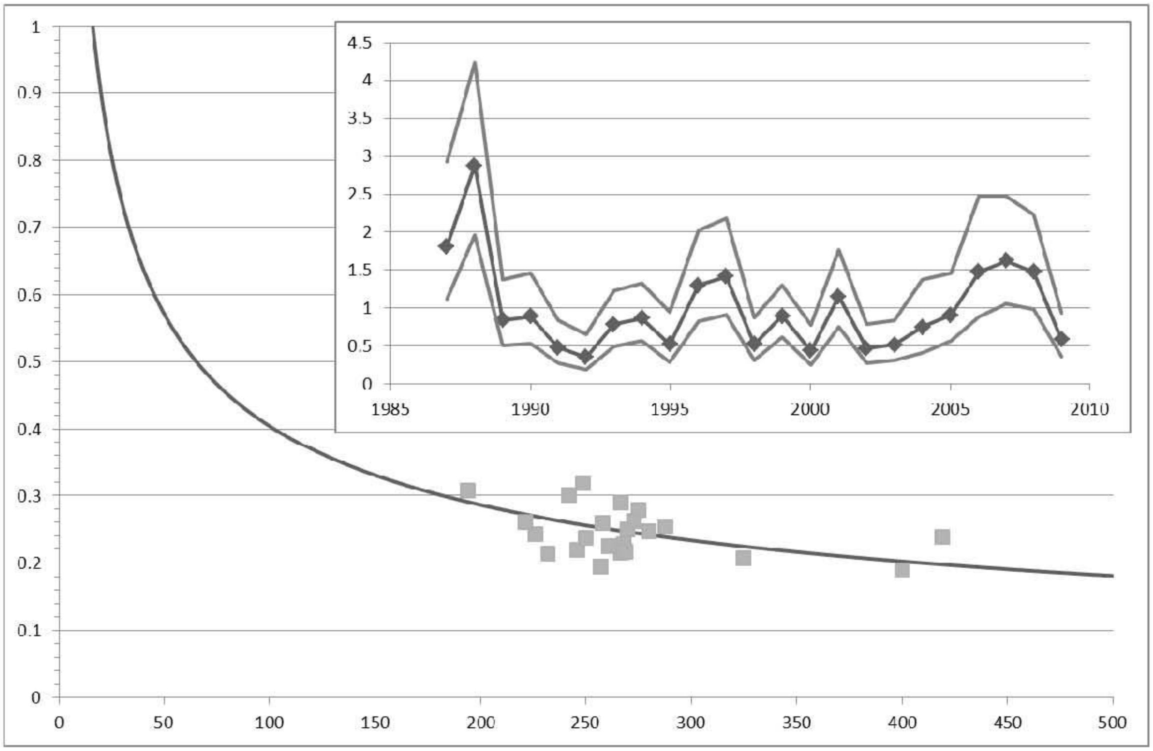


Spot



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1
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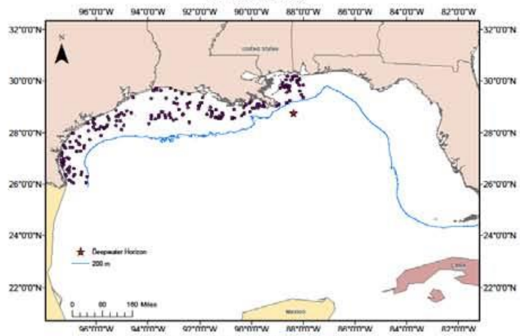
0
1985
1990
1995
2000
2005
2010

Rough Scad

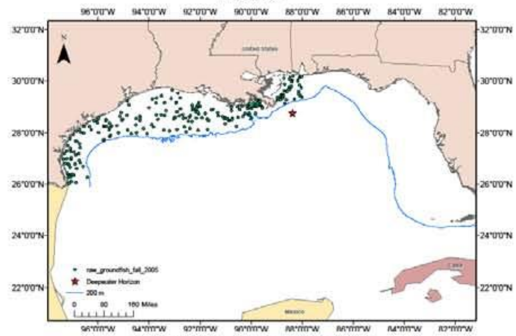
BOTTOM TRAWL SURVEY EFFORT

By Year and Season:

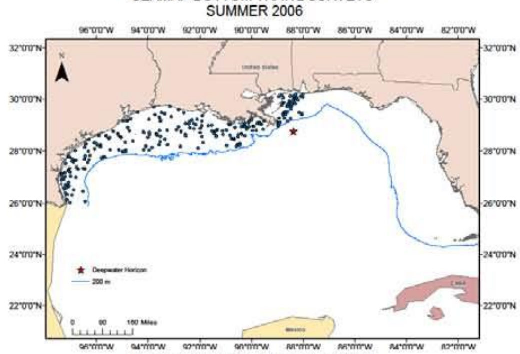
SEAMAP BOTTOM TRAWL SURVEYS
SUMMER 2005



SEAMAP BOTTOM TRAWL SURVEYS
FALL 2005



SEAMAP BOTTOM TRAWL SURVEYS
SUMMER 2006



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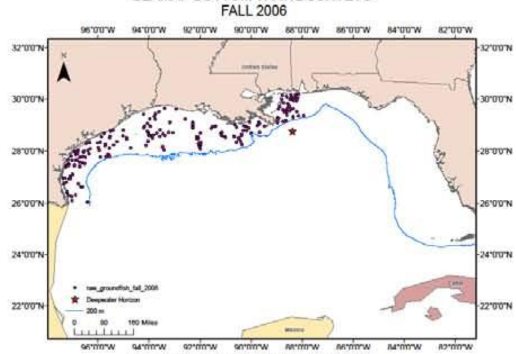
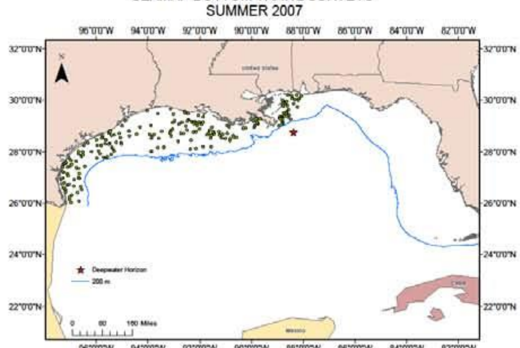
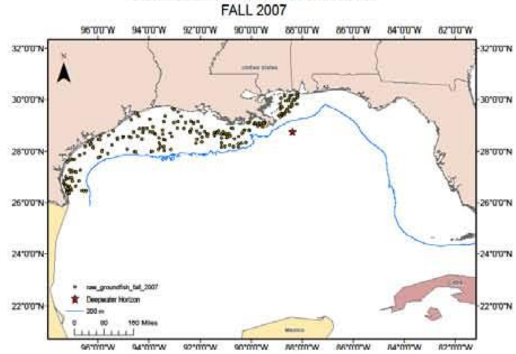
FALL 2006



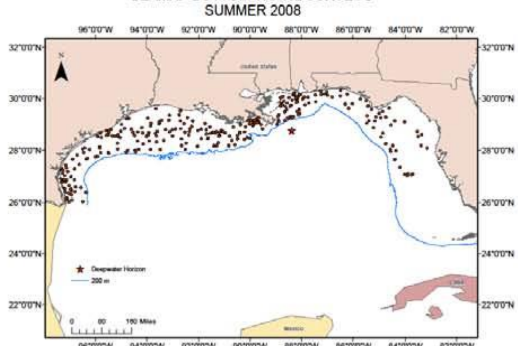
SEAMAP BOTTOM TRAWL SURVEYS
SUMMER 2007



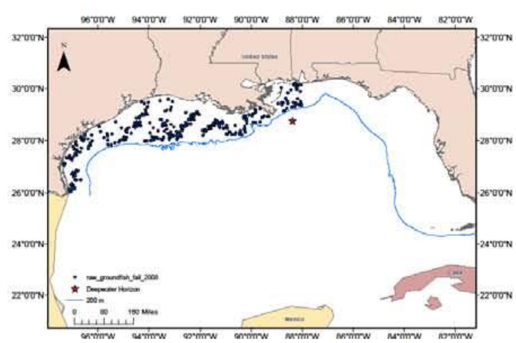
SEAMAP BOTTOM TRAWL SURVEYS
FALL 2007



SEAMAP BOTTOM TRAWL SURVEYS
SUMMER 2008



SEAMAP BOTTOM TRAWL SURVEYS - FALL 2008



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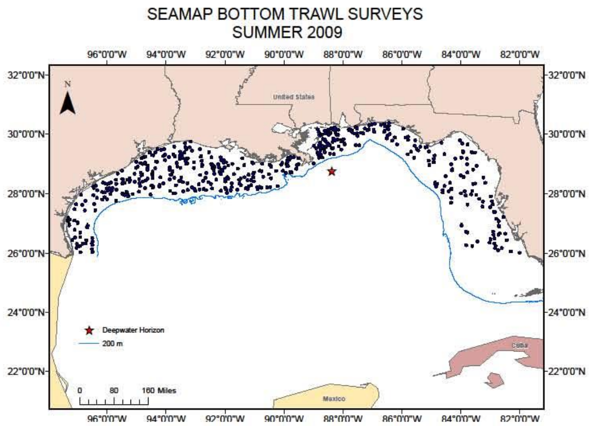
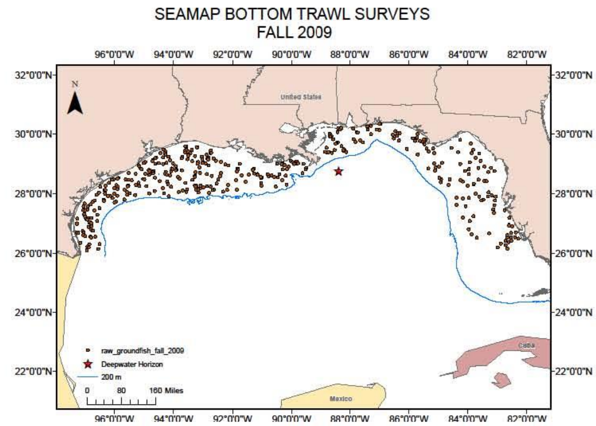
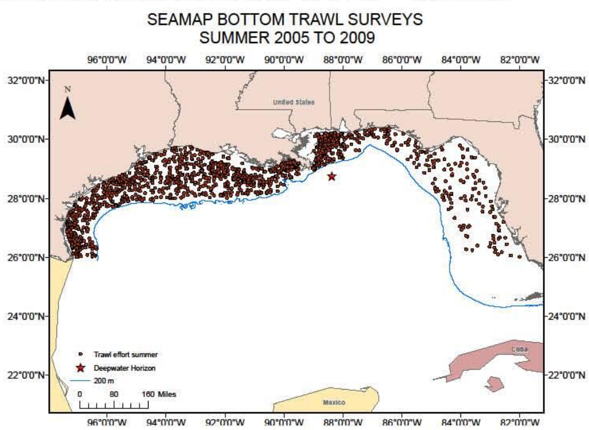
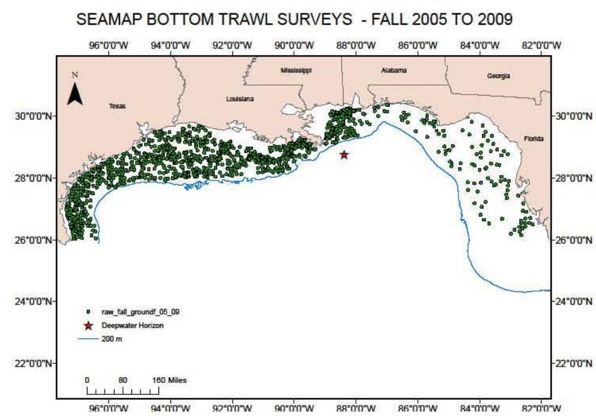




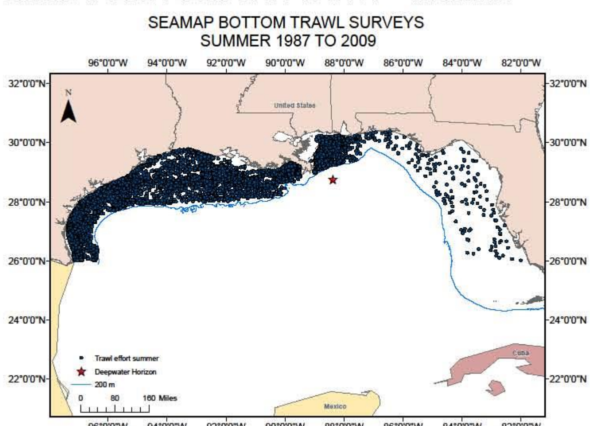
Combined effort from 2005 to 2009 – summer:



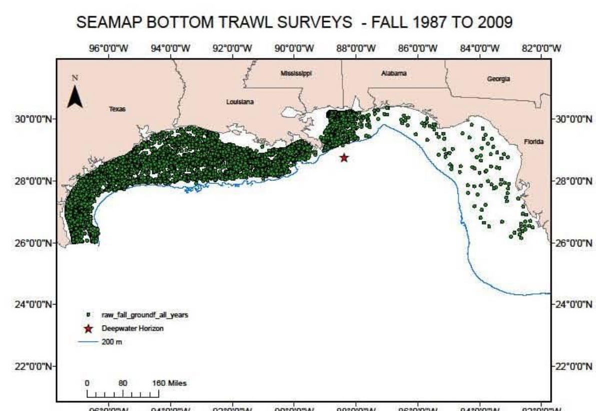
Combined effort from 2005 to 2009 – fall:



Combined effort from 1987 to 2009 – summer:



Combined effort from 1987 to 2009 – fall:



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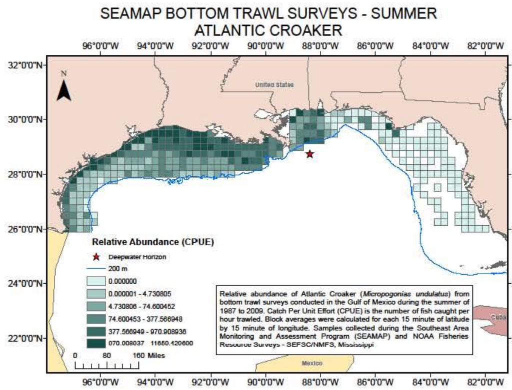
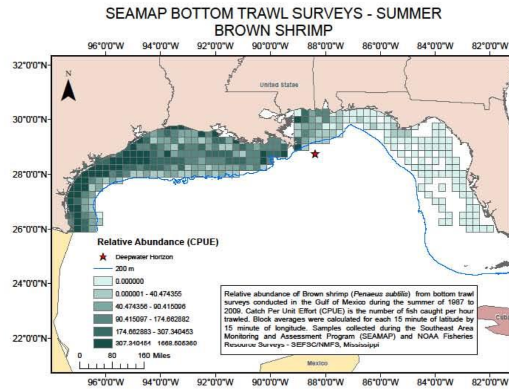
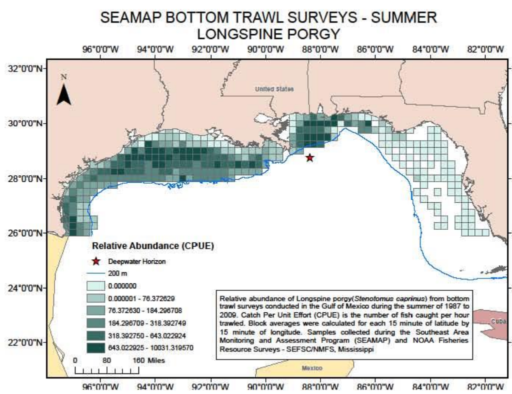
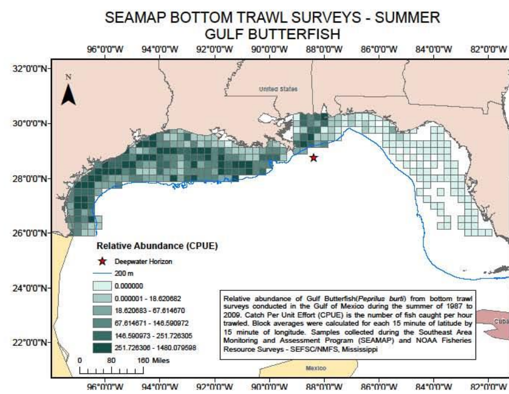
BOTTOM TRAWL DOMINANT SPECIES – SUMMER









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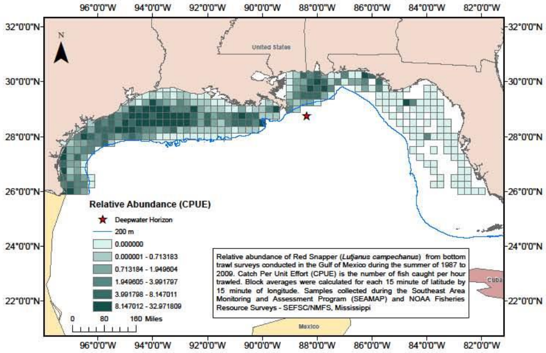
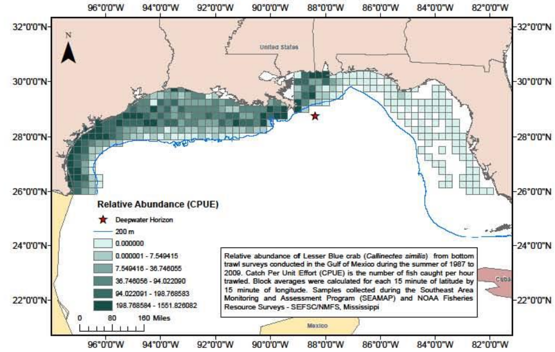
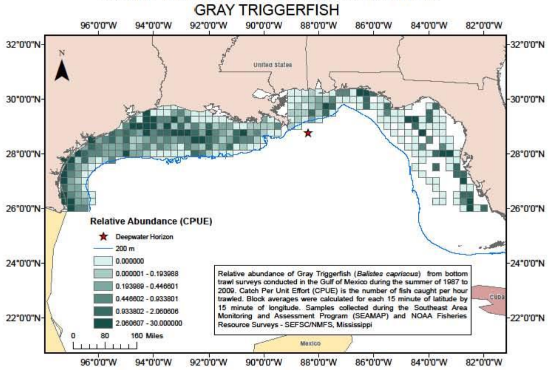
SEAMAP BOTTOM TRAWL SURVEYS - SUMMER
RED SNAPPER



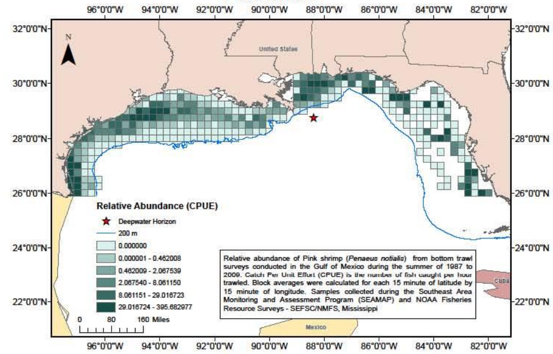
SEAMAP BOTTOM TRAWL SURVEYS - SUMMER
LESSER BLUE CRAB



SEAMAP BOTTOM TRAWL SURVEYS - SUMMER
GRAY TRIGGERFISH



SEAMAP BOTTOM TRAWL SURVEYS - SUMMER
PINK SHRIMP



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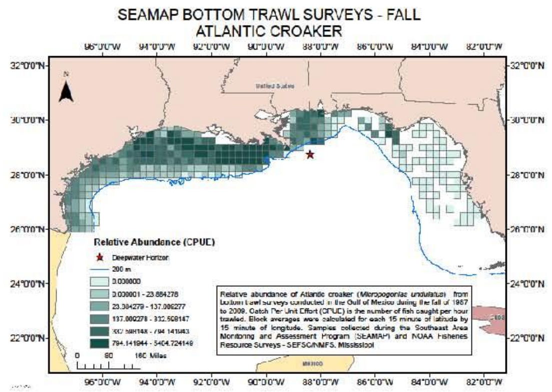
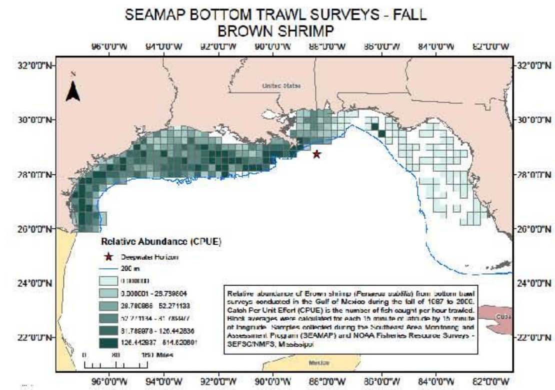
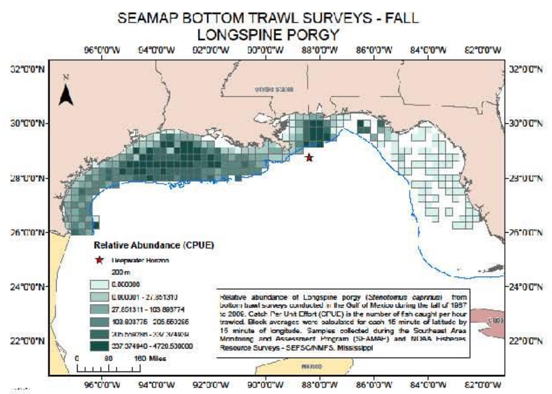
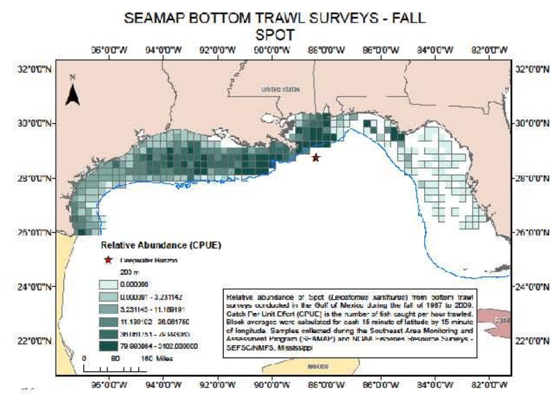
Prepared by: Paula Moreno
9/14/2010, Version 1

BOTTOM TRAWL DOMINANT SPECIES – FALL









NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

Prepared by: Paula Moreno
9/14/2010, Version 1

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

REEF FISH SURVEYS

NOAA Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories,
Resource Surveys Branch

Prepared by: Terry Henwood, Paula Moreno, Walter Ingram, Chris Gledhill

NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

CONTENTS

- Overview of survey gear, temporal and spatial coverage, survey design
- Tables with dominant species caught (CPUE and occurrence)
- Coefficient of Variation (CV) of the mean plots and index plots
- Maps with sampling locations and abundance of dominant species

NOAA Fisheries Service
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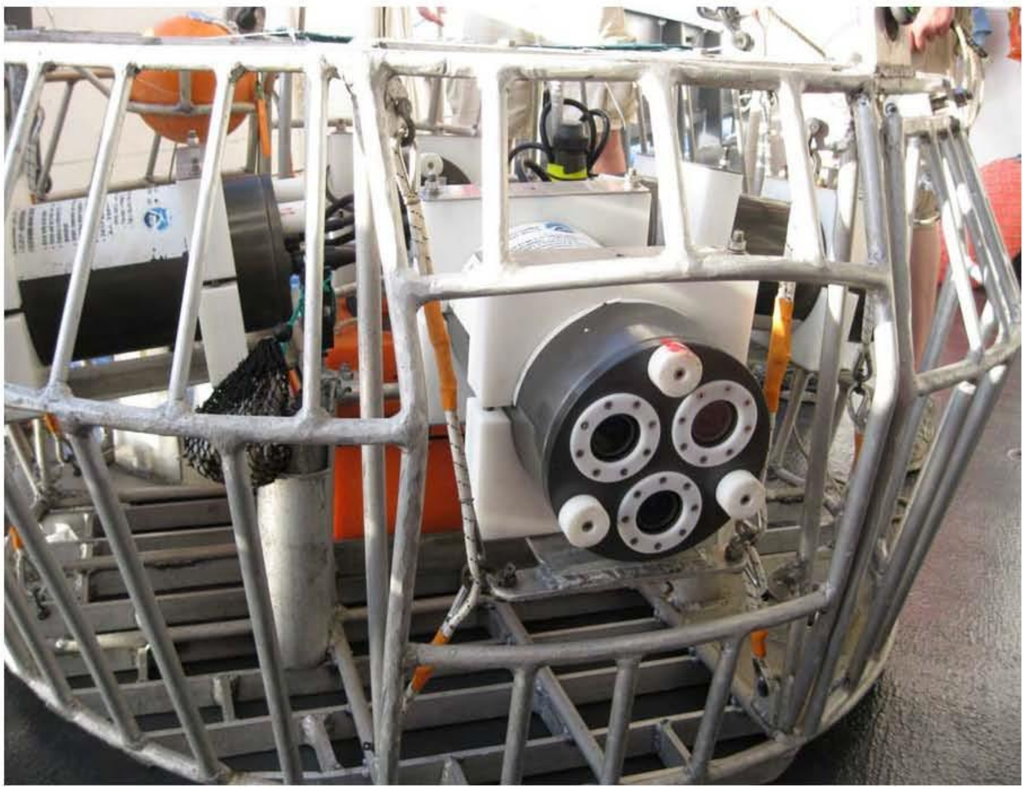
Reef Fish Surveys

Reef Fish Camera Array



Gear:

- From 1992 to 2007, the SEAMAP reef fish survey used video camcorders. The models of camcorders used changed over time. The most recent were Sony VX2000 DCR digital camcorders mounted in Gates PD150M underwater housings.
- The housings are rated to a maximum depth of 150 meters. The camcorders are mounted orthogonally and a height of 30 cm above the bottom in a camera array.
- In 2008, the camcorders were replaced by a digital camera system comprised of stereo still cameras and a CCD camera. Four of these stereo camera systems are mounted in an array (see Figure above).

Years Conducted:

- The offshore reef fish survey was initiated in 1992, with sampling conducted during the months of May to August from 1992-1997, and in 2001-2002, 2004-2010. No surveys were conduced from 1998 to 2000 and in 2003.

Depth Range:

- 10 to 150 meters

Survey Design:

- A two-stage sampling design is used to minimize travel times between sample stations. The first-stage or primary sampling units (PSUs) are blocks 10 minutes of latitude by 10 minutes of longitude. The first-stage units are selected by stratified random sampling. The ultimate sample sites (second stage units) within a block are selected randomly.
- The blocks were stratified, with strata defined by geographic region (4 regions: South Florida, Northeast Gulf, Louisiana-Texas Shelf, and SouthTexas), and by reef habitat area (Blocks ≤ 20 km² reef, Block > 20 km² reef). There are a total of 7 strata.

CV and Index Plots for Species with Highest Catch Rates from the Reef Fish Video Survey

For each species, the smaller graph is of annual relative abundance indices (with 95% confidence intervals) with relative abundance on the vertical axis and survey year on the horizontal axis. The larger graph consists of two plots with CV (coefficient of variation of the mean index value) on the vertical axis and sample size on the horizontal axis. The continuous line represents a theoretical CV by sample size, which is based on the points therein. The points represent actual CV values and survey sample sizes.

NOTE:

The time series extends from 1993 since minimum counts were not determined in 1992, and the 1992 video tapes can not be re-viewed because they were destroyed during Hurricane Katrina.

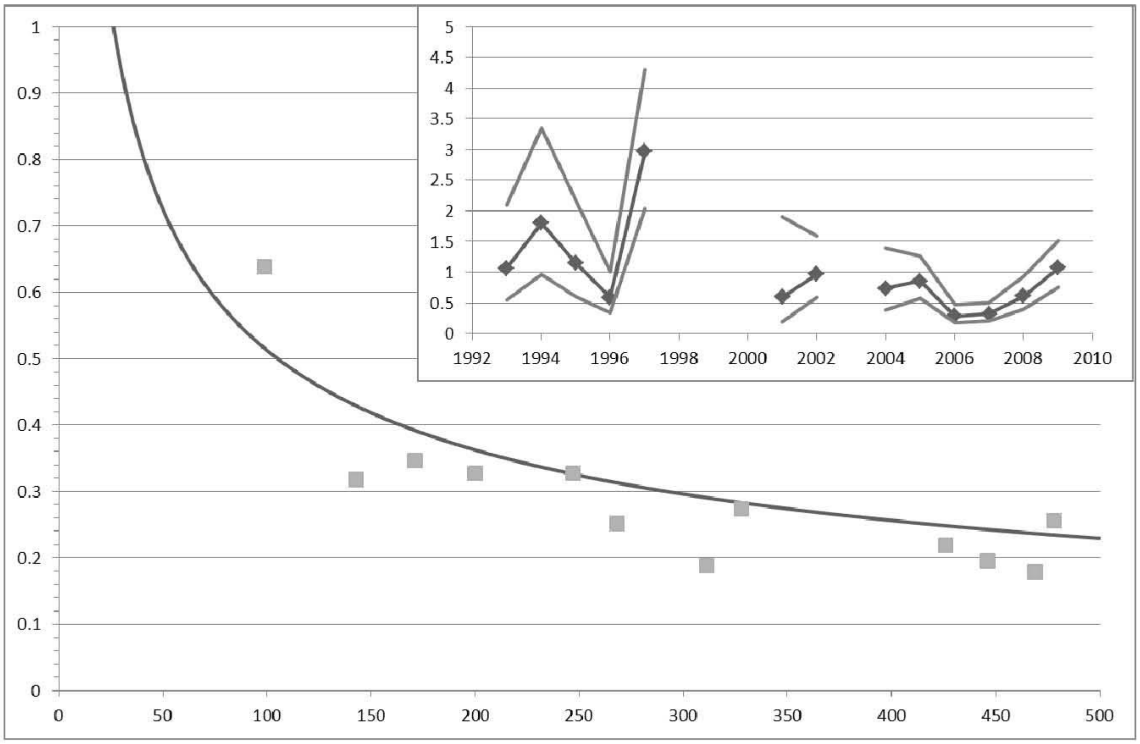
Top 20 species sorted by observation rate (mincount per 20 minutes of video) observed during the NMFS Reef Fish Video Survey 1993-2009.

Rank	*Taxon*	*Common Name*	*Observation Rate*
1	*Rhomboplites aurorubens*	Vermilion snapper	2.15131
2	*Pagrus pagrus*	Red porgy	1.25210
3	*Mycteroperca phenax*	Scamp	0.63985
4	*Seriola dumerili*	Greater amberjack	0.53157
5	*Lutjanus campechanus*	Red snapper	0.50164
6	*Seriola rivoliana*	Almaco jack	0.43241
7	*Lutjanus griseus*	Gray snapper	0.34004
8	*Ocyurus chrysurus*	Yellowtail snapper	0.27526
9	*Balistes capriscus*	Gray triggerfish	0.24684
10	*Epinephelus morio*	Red grouper	0.20346
11	*Seriola fasciata*	Lesser amberjack	0.08630
12	*Mycteroperca microlepis*	Gag	0.06922
13	*Mycteroperca interstitialis*	Yellowmouth grouper	0.05449
14	*Lutjanus synagris*	Lane snapper	0.04560
15	*Cephalopholis cruentata*	Graysby	0.04350
16	*Lutjanus analis*	Mutton snapper	0.03906
17	*Epinephelus adscensionis*	Rock hind	0.02409
18	*Epinephelus guttatus*	Red hind	0.00935
19	*Lutjanus apodus*	Schoolmaster	0.00842
20	*Lutjanus vivanus*	Silk snapper	0.00842

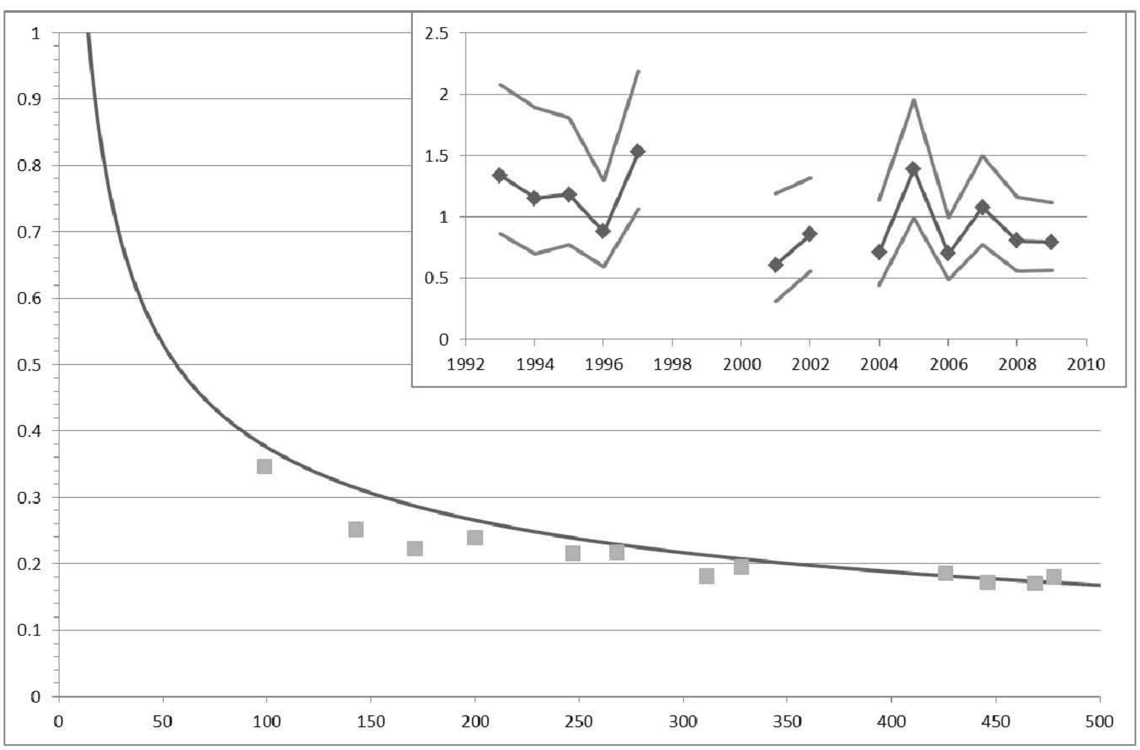
Top 20 species sorted by frequency of occurrence during the NMFS Reef Fish Video Survey 1993-2009.

Rank	*Taxon*	*Common Name*	*Frequency*
1	*Pagrus pagrus*	Red porgy	0.27105
2	*Mycteroperca phenax*	Scamp	0.21422
3	*Seriola rivoliana*	Almaco jack	0.17820
4	*Lutjanus campechanus*	Red snapper	0.17540
5	*Seriola dumerili*	Greater amberjack	0.17072
6	*Epinephelus morio*	Red grouper	0.16113
7	*Rhomboplites aurorubens*	Vermilion snapper	0.15903
8	*Balistes capriscus*	Gray triggerfish	0.14406
9	*Lutjanus griseus*	Gray snapper	0.08746
10	*Ocyurus chrysurus*	Yellowtail snapper	0.05122
11	*Mycteroperca microlepis*	Gag	0.04701
12	*Mycteroperca interstitialis*	Yellowmouth grouper	0.03672
13	*Cephalopholis cruentata*	Graysby	0.03204
14	*Lutjanus analis*	Mutton snapper	0.03134
15	*Seriola fasciata*	Lesser amberjack	0.03087
16	*Lutjanus synagris*	Lane snapper	0.02105
17	*Epinephelus adscensionis*	Rock hind	0.01567
18	*Epinephelus guttatus*	Red hind	0.00702
19	*Mycteroperca venenosa*	Yellowfin grouper	0.00585
20	*Lutjanus apodus*	Schoolmaster	0.00514

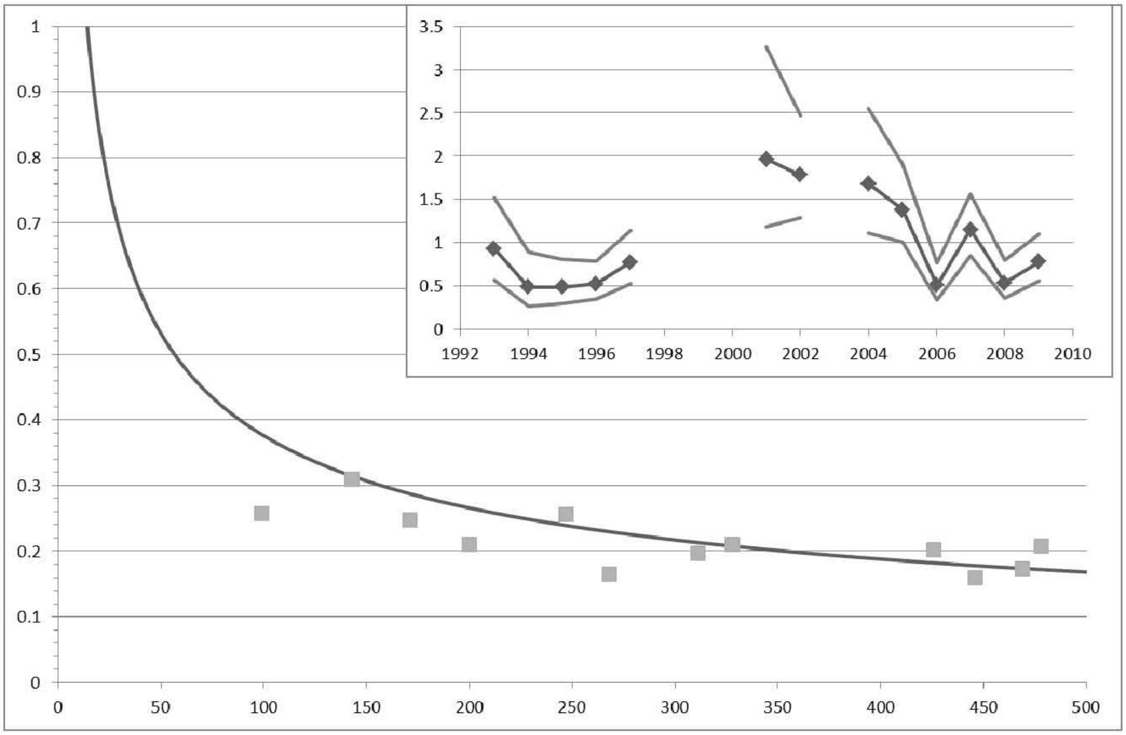
CV PLOTS



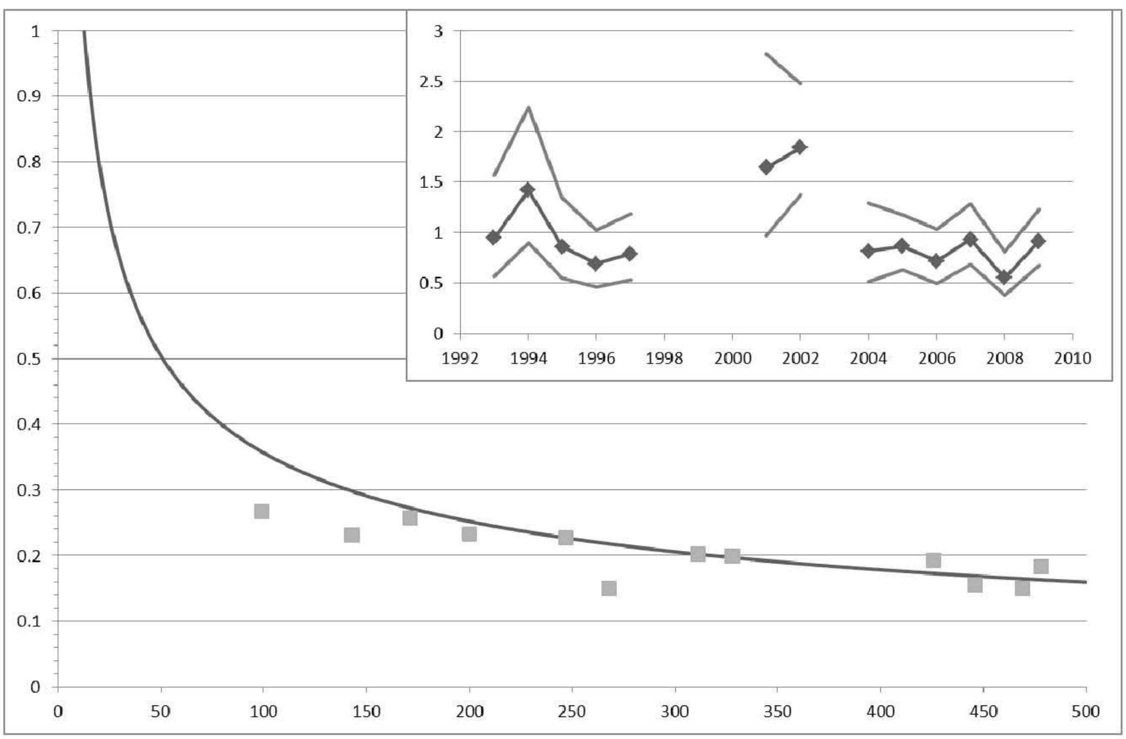
Vermilion Snapper



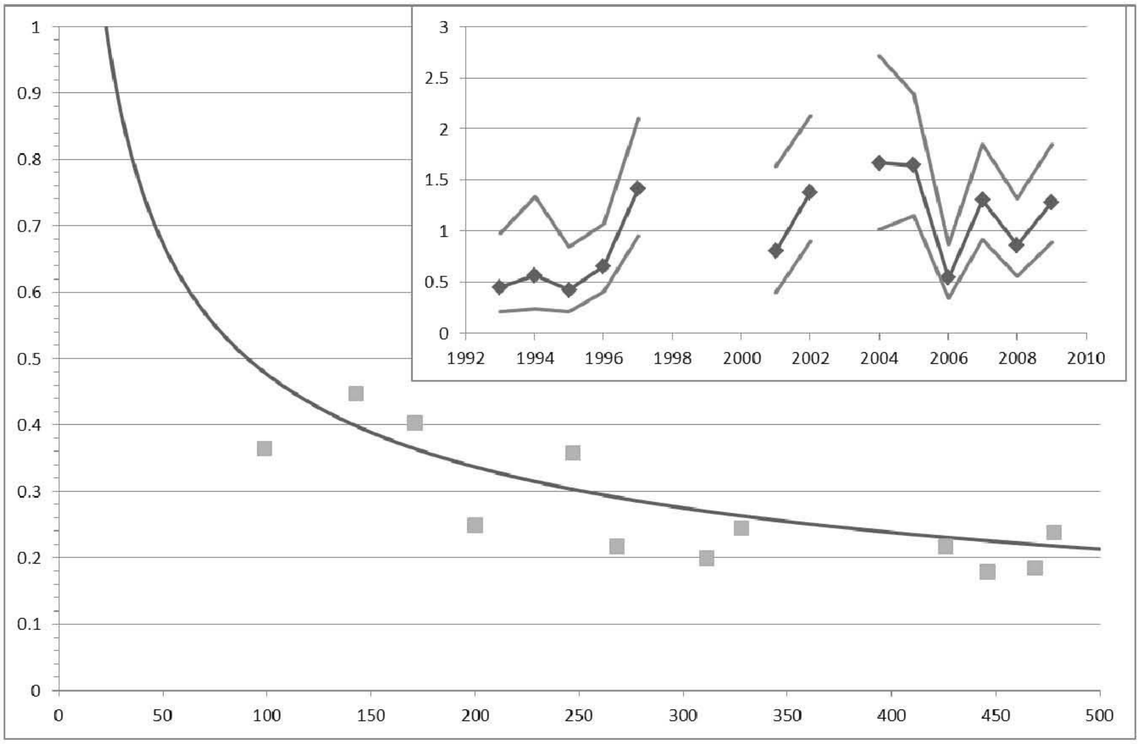
Red Porgy



Scamp



Greater Amberjack



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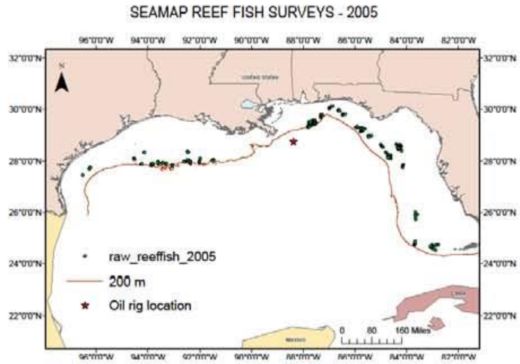
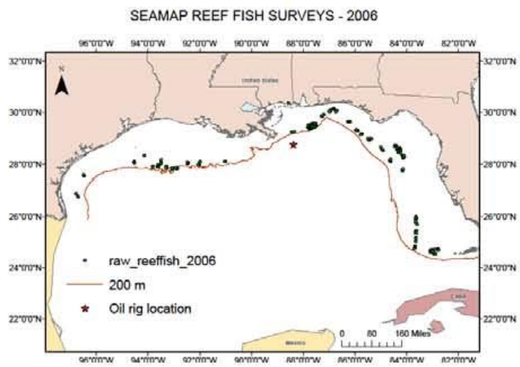
1992 1994 1996 1998 2000 2002 2004 2006 2008 2010

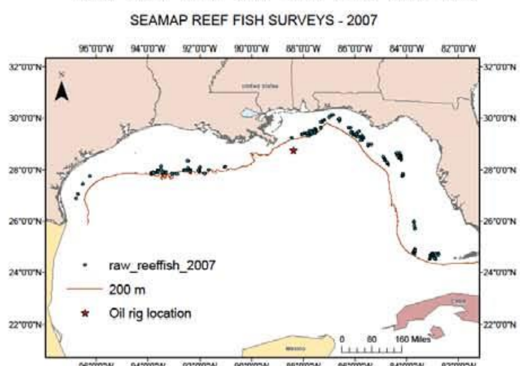
Red Snapper

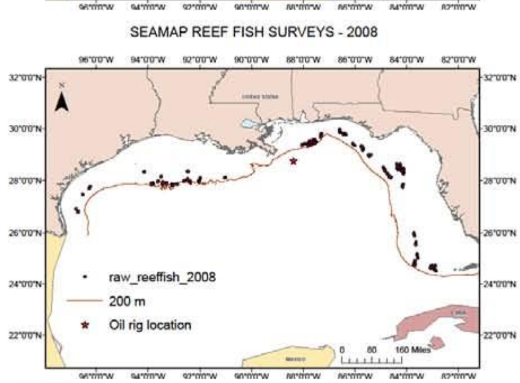
REEF FISH SURVEY EFFORT

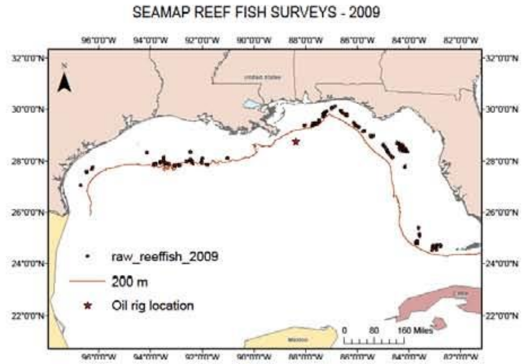
By Year:











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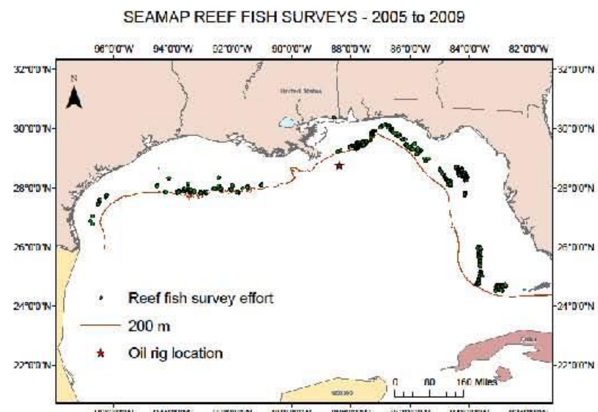
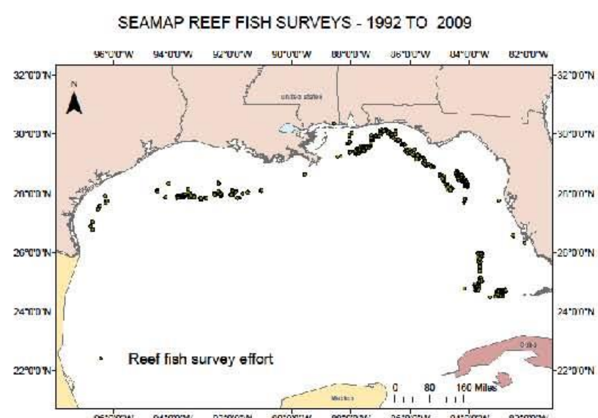


Combined effort from 1992 to 2009:



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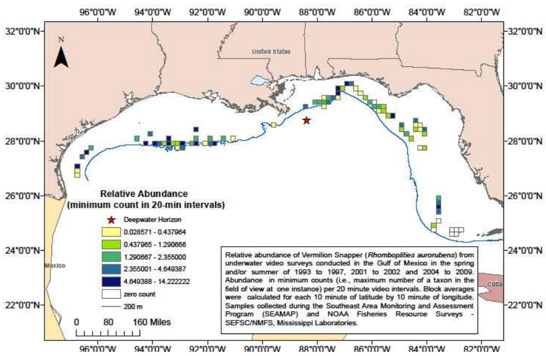
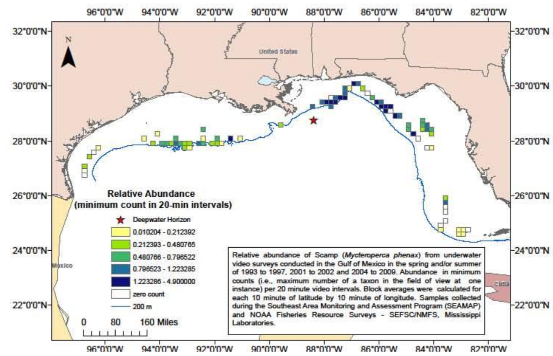
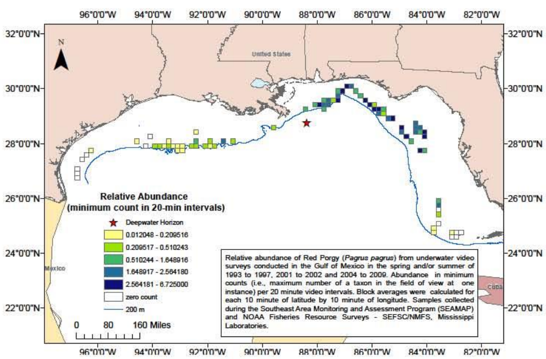
SEAMAP REEF FISH SURVEYS - VERMILION SNAPPER



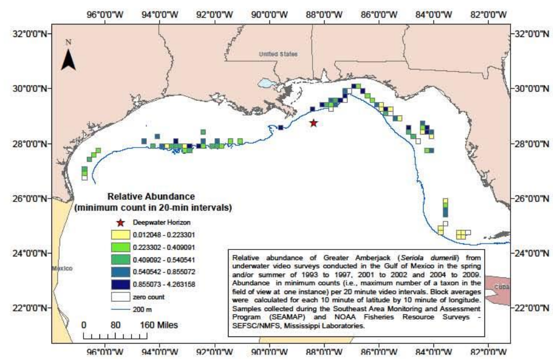
SEAMAP REEF FISH SURVEYS - SCAMP



SEAMAP REEF FISH SURVEYS - RED PORGY



SEAMAP REEF FISH SURVEYS - GREATER AMBERJACK



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Southeast Fisheries Science Center
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Prepared by: Paula Moreno
9/14/2010, Version 1

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

SMALL PELAGICS/DEEP WATER TRAWL SURVEYS

NOAA Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories, Resource Surveys Branch

Prepared by: Terry Henwood, Paula Moreno, Walter Ingram, Gilmore Pellegrin Jr.

NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

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NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

Small Pelagics/Deep Water Trawl Surveys

Retrieving 90 ft. Pelagic Trawl

Cod End

Catch on Deck

Gear:

- At trawling stations, the ship conducts one tow with the 90-ft high-opening bottom trawl (HOBT). Each HOBT is towed for 30 minutes after the gear has sufficiently settled on the bottom as determined by the net mensuration system, descent rate charts or by the deck crew.
- The net is towed at approximately 3 to 3.5 knots, and exact tow speed is determined by the behavior of the gear (i.e., the head rope needs to be fished at 8 m from the bottom, and the foot rope needs to remain near the bottom)
- At the end of the 30-minute tow, the ship is requested to quickly increase speed to 5 knots for 2-5 minutes. This pulse helps to force fish remaining in the net into the cod end.

Years Conducted:

- Current survey began in October of 2002 as an outer shelf and upper slope survey (i.e. between 110 and 500 m station depth).
- Trawling stations began to be allocated in shallower depth strata to allow geographic overlap with SEAMAP groundfish effort.
- By 2004, the survey became a mid- to outer- shelf and upper slope survey.
- Due to consistent gear damage in statistical zones 1-3, these areas were dropped in 2004, resulting in coverage between Brownsville, Texas and Sarasota, Florida.

Depth Range:

- 50 and 500 m station depth.

Survey Design:

<u>Initial Survey Design</u>

- The borders of the existing SEAMAP Gulf of Mexico statistical zones are extended until crossing the 110, 200 and 500 m depth contours.
- The areas between depth contours (i.e. 110-200 m and 200-500 m) within each statistical zone are calculated.
- Using proportional allocation based on above calculated areas, 150 stations are randomly positioned with 90% placed between 110 and 200 m and 10% placed between 200 and 500 m.

<u>Current Survey Design</u>

- The borders of existing SEAMAP Gulf of Mexico statistical zones are extended until crossing the 50 m, 110 m, 200 m and 500 m depth contours.
- The areas between depth contours (i.e. 50-110 m, 110-200 m and 200-500 m) within each statistical zone are calculated using proportional allocation based on above calculated areas with 30% placed between 50 and 110 m, 60% placed between 110 and 200 m, 10% placed between 200 and 500 m.
- Stratification is by shrimp statistical zone and by depth strata.

CV and Index Plots for Species with Highest Catch Rates from the Small Pelagics/Deep Water Trawl Survey

For each species, the smaller graph is of annual relative abundance indices (with 95% confidence intervals) with relative abundance on the vertical axis and survey year on the horizontal axis. The larger graph consists of two plots with CV (coefficient of variation of the mean index value) on the vertical axis and sample size on the horizontal axis. The continuous line represents a theoretical CV by sample size, which is based on the points therein. The points represent actual CV values and survey sample sizes.

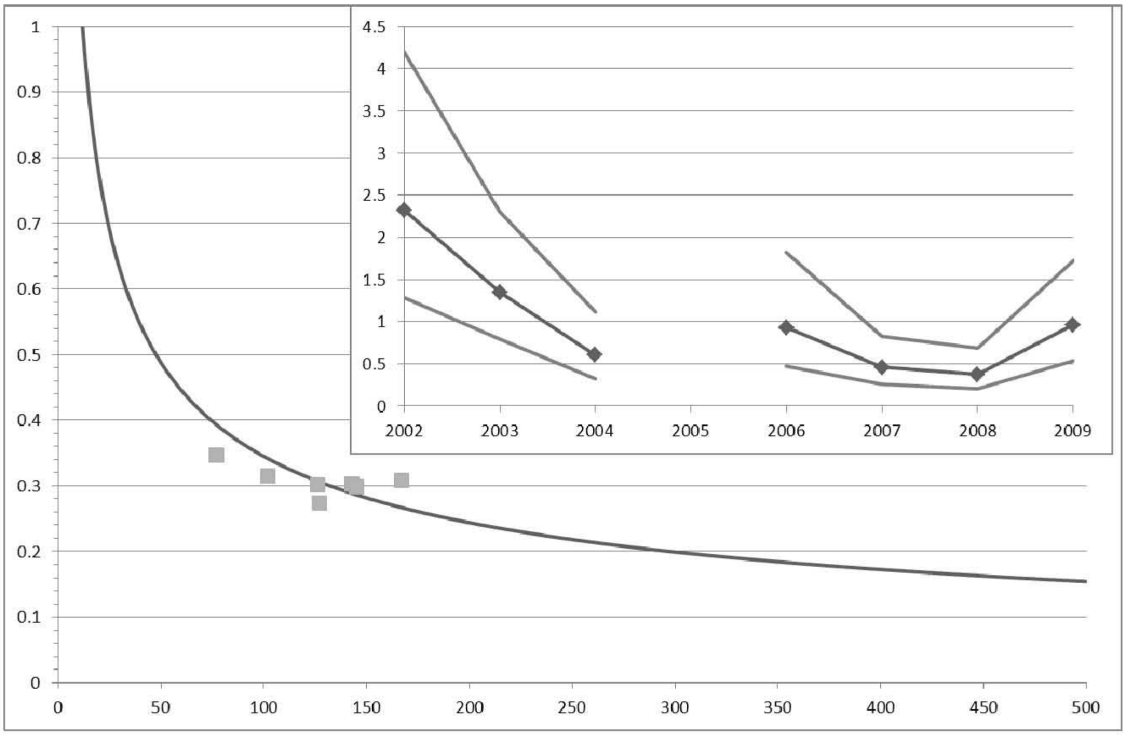
Top 20 species sorted by catch rate (number per trawl-hour) collected during the NMFS Small Pelagics/Deep Water Trawl Survey 2002-2009.

Rank	*Taxon*	*Common Name*	*Catch Rate*
1	*Trachurus lathami*	Rough scad	785.664
2	*Etrumeus teres*	Round herring	453.617
3	*Stenotomus caprinus*	Longspine porgy	447.852
4	*Peprilus burti*	Gulf butterfish	389.586
5	*Pristipomoides aquilonaris*	Wenchman	197.032
6	*Loligo pealei*	Long-finned squid	191.534
7	*Saurida normani*	Shortjaw lizardfish	82.749
8	*Upeneus parvus*	Dwarf goatfish	73.080
9	*Lagodon rhomboides*	Pinfish	72.964
10	*Trichiurus lepturus*	Atlantic cutlassfish	64.727
11	*Saurida brasiliensis*	Largescale lizardfish	63.920
12	*Parapenaeus politus*	Rose shrimp	58.651
13	*Mullus auratus*	Red goatfish	55.829
14	*Micropogonias undulatus*	Atlantic croaker	54.408
15	*Serranus atrobranchus*	Blackear bass	51.418
16	*Prionotus stearnsi*	Shortwing searobin	46.183
17	*Ariomma bondi*	Silver-rag driftfish	46.141
18	*Polymixia lowei*	Beardfish	40.463
19	*Steindachneria argentea*	Luminous hake	29.598
20	*Rhomboplites aurorubens*	Vermilion snapper	29.424

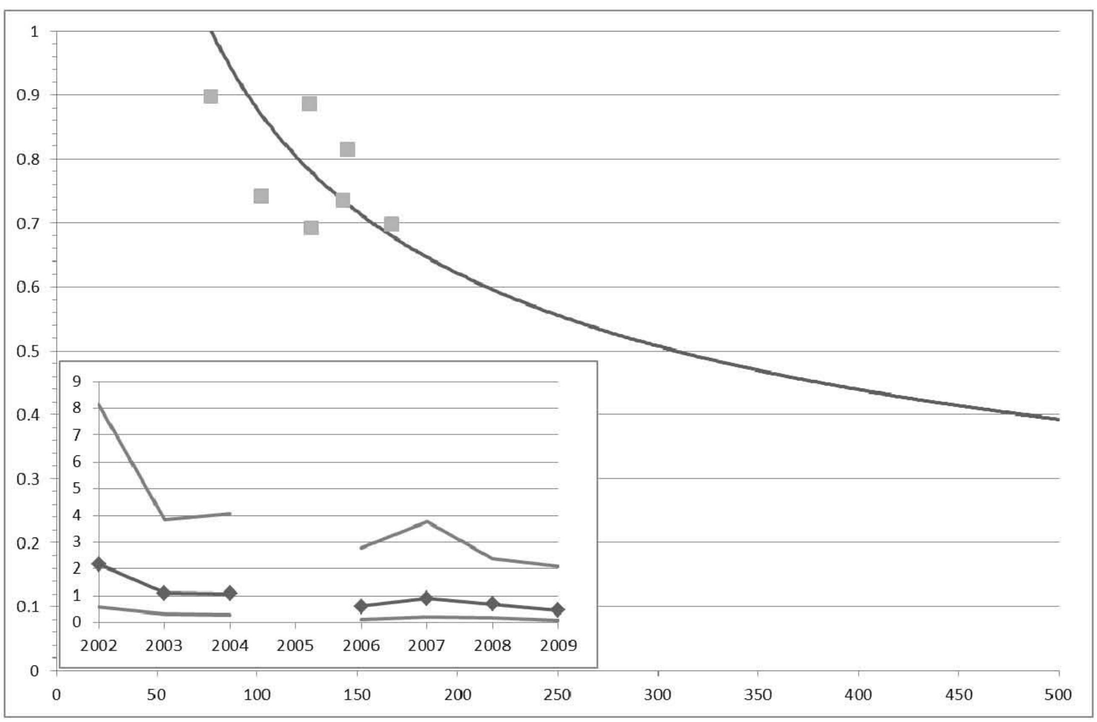
Top 20 species sorted by frequency of occurrence during the NMFS Small Pelagics/Deep Water Trawl Survey 2002-2009.

Rank	*Taxon*	*Common Name*	*Frequency*
1	*Loligo pealei*	Long-finned squid	0.79143
2	*Trachurus lathami*	Rough scad	0.71139
3	*Pristipomoides aquilonaris*	Wenchman	0.66742
4	*Prionotus stearnsi*	Shortwing searobin	0.43630
5	*Saurida brasiliensis*	Largescale lizardfish	0.39572
6	*Saurida normani*	Shortjaw lizardfish	0.37542
7	*Squatina demerili*	Atlantic angel shark	0.36528
8	*Peprilus burti*	Gulf butterfish	0.36528
9	*Stenotomus caprinus*	Longspine porgy	0.33709
10	*Upeneus parvus*	Dwarf goatfish	0.33596
11	*Prionotus longispinosus*	Bigeye searobin	0.33258
12	*Solenocera vioscai*	Humpback shrimp	0.29425
13	*Trichiurus lepturus*	Atlantic cutlassfish	0.28749
14	*Ariomma bondi*	Silver-rag driftfish	0.27734
15	*Portunus spinicarpus*	Longspine swimming crab	0.26945
16	*Prionotus paralatus*	Mexican searobin	0.26381
17	*Lagodon rhomboides*	Pinfish	0.24690
18	*Mullus auratus*	Red goatfish	0.23675
19	*Scorpaena agassizii*	Longfin scorpionfish	0.23112
20	*Prionotus alatus*	Spiny searobin	0.22097

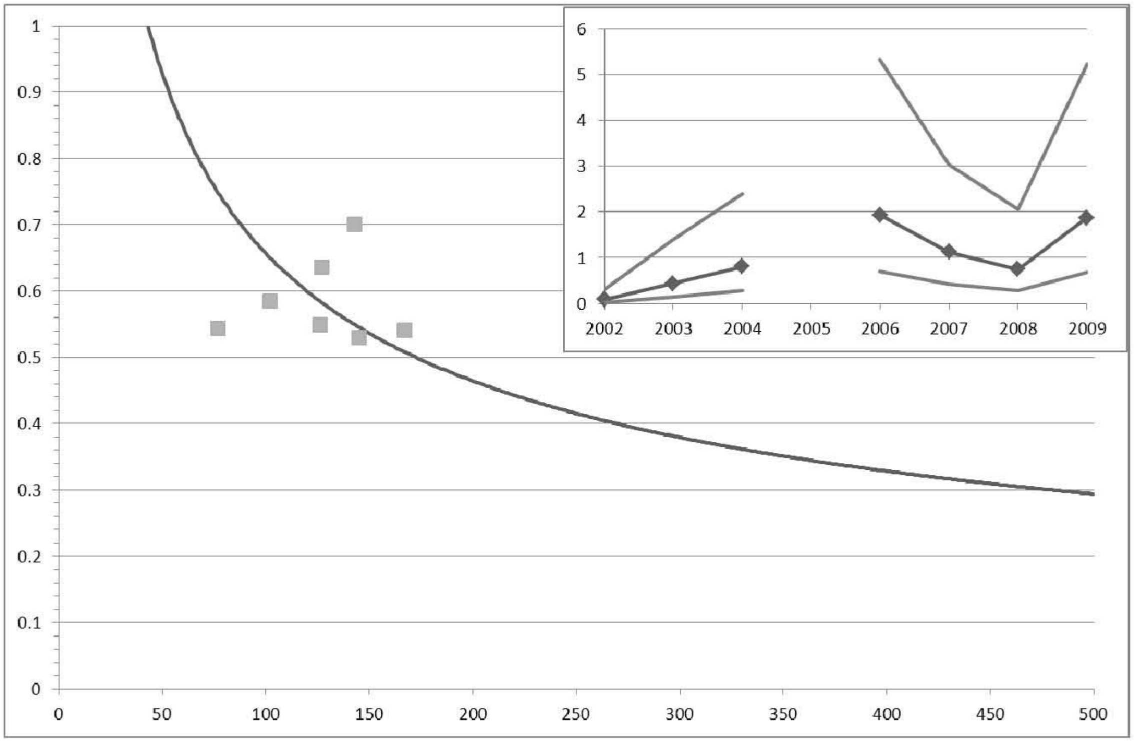
CV PLOTS



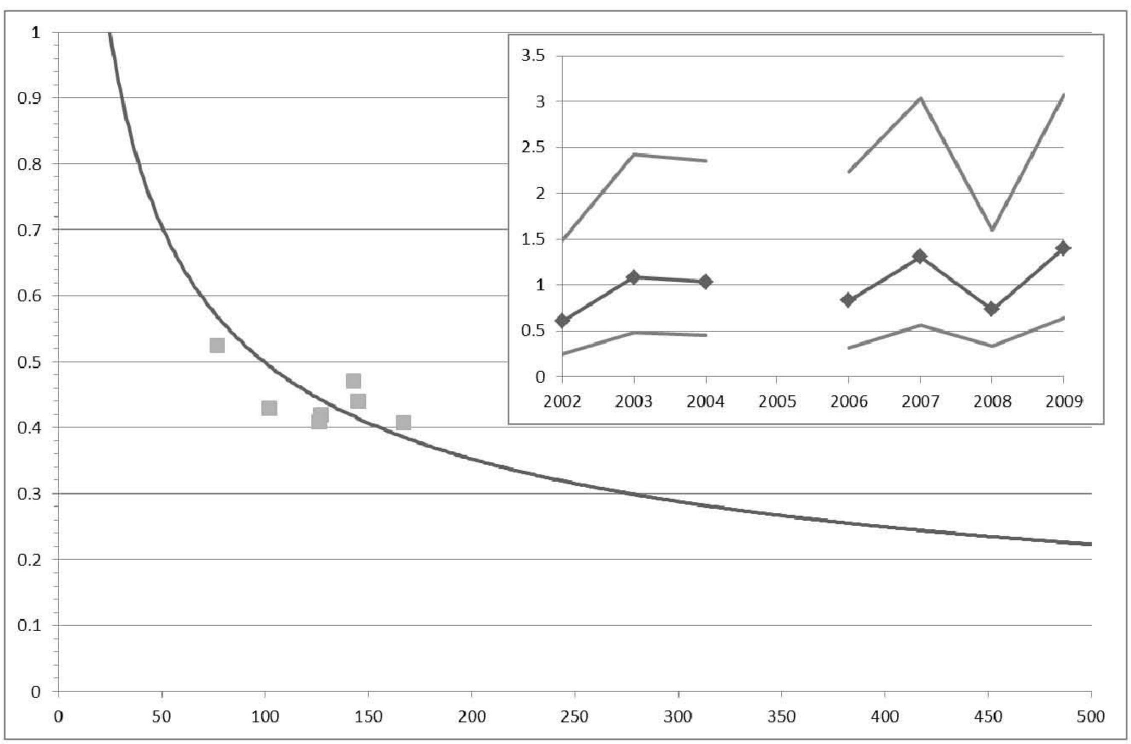
TRACHUR_LATHA



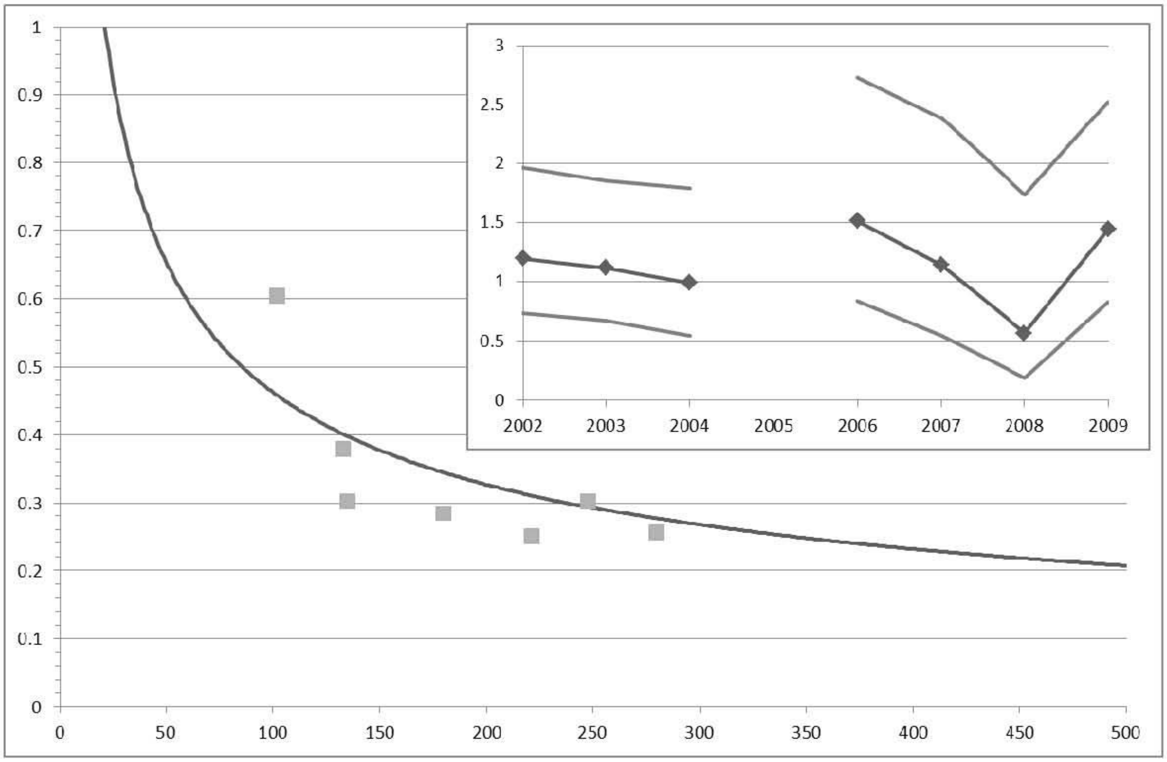
ETRUMEU_TERES



STENOTO_CAPRI



PEPRILU_BURTI

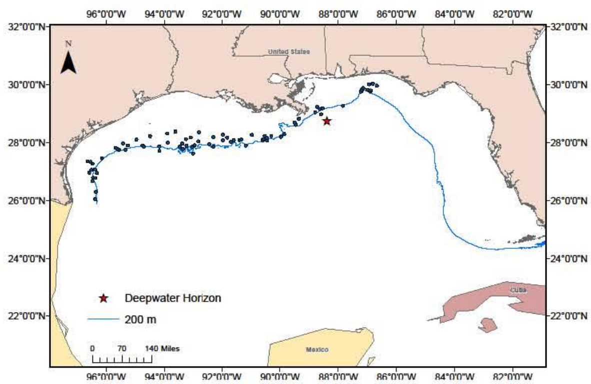


PRISTIP_AQUIL

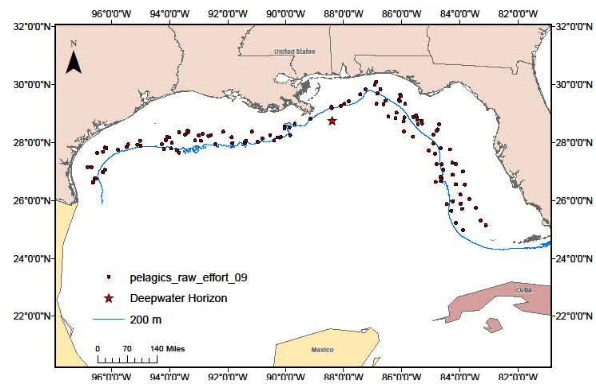
SMALL PELAGICS SURVEY EFFORT

By Year:

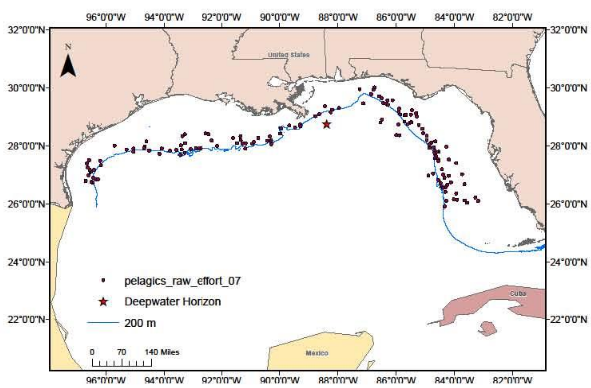
SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - 2006



SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - 2009

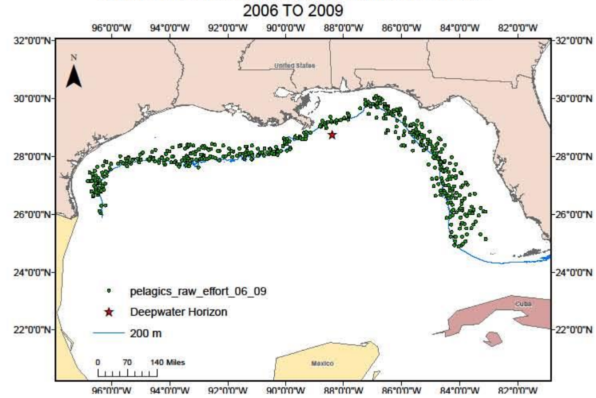


SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - 2007

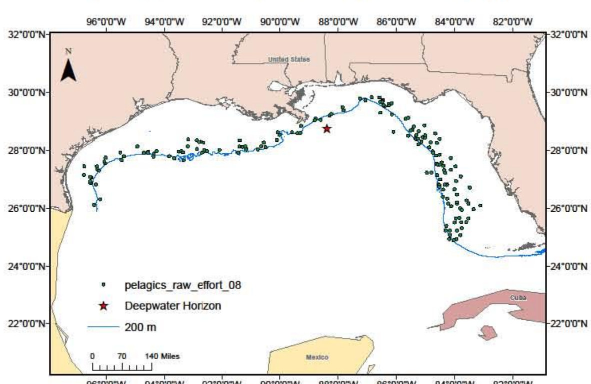


Combined effort from 2006 to 2009:

SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - 2006 TO 2009

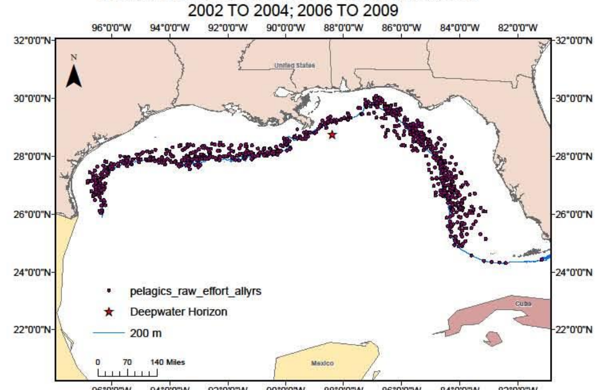


SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - 2008



Combined effort from 2002-2004 and 2006-2009:

SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - 2002 TO 2004; 2006 TO 2009



NOAA Fisheries Service
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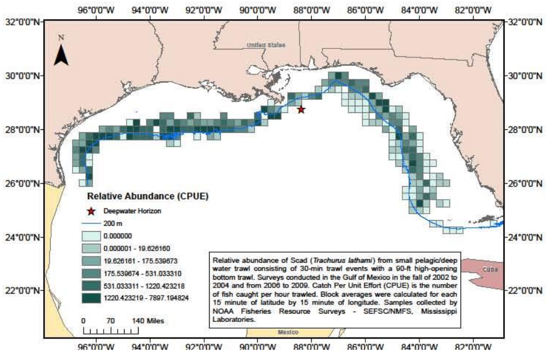
Mississippi Laboratories

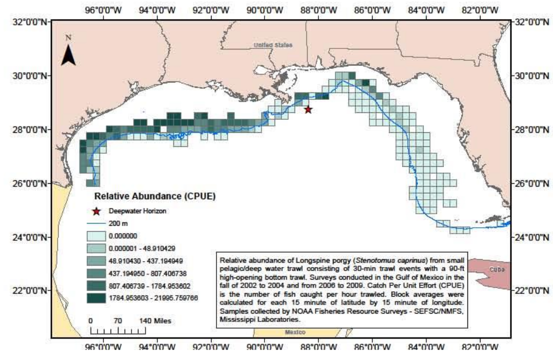
Prepared by: Paula Moreno
9/14/2010, Version 1

SMALL PELAGICS DOMINANT SPECIES

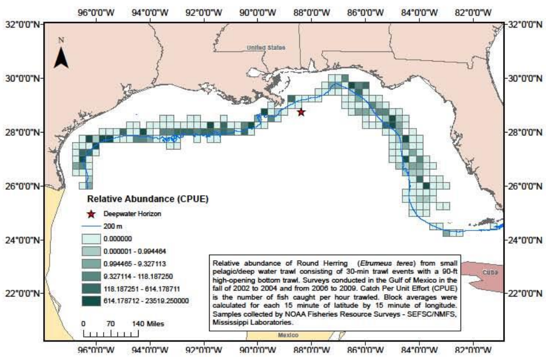
SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - SCAD



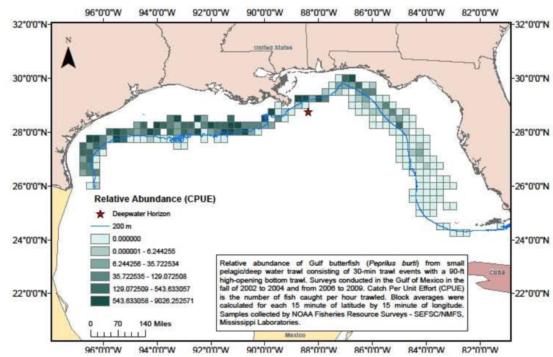
SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - LONGSPINE PORGY



SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - GULF ROUND HERRING



SMALL PELAGICS/DEEP WATER TRAWL SURVEYS - GULF BUTTERFISH



NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

Prepared by: Paula Moreno
9/14/2010, Version 1

For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

Map of surface oil concentration estimation
And
Overview of Response Cruises

NOAA Fisheries Service, Southeast Fisheries Science Center, Mississippi Laboratories,
Resource Surveys Branch

Compiled by: Paula Moreno

NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

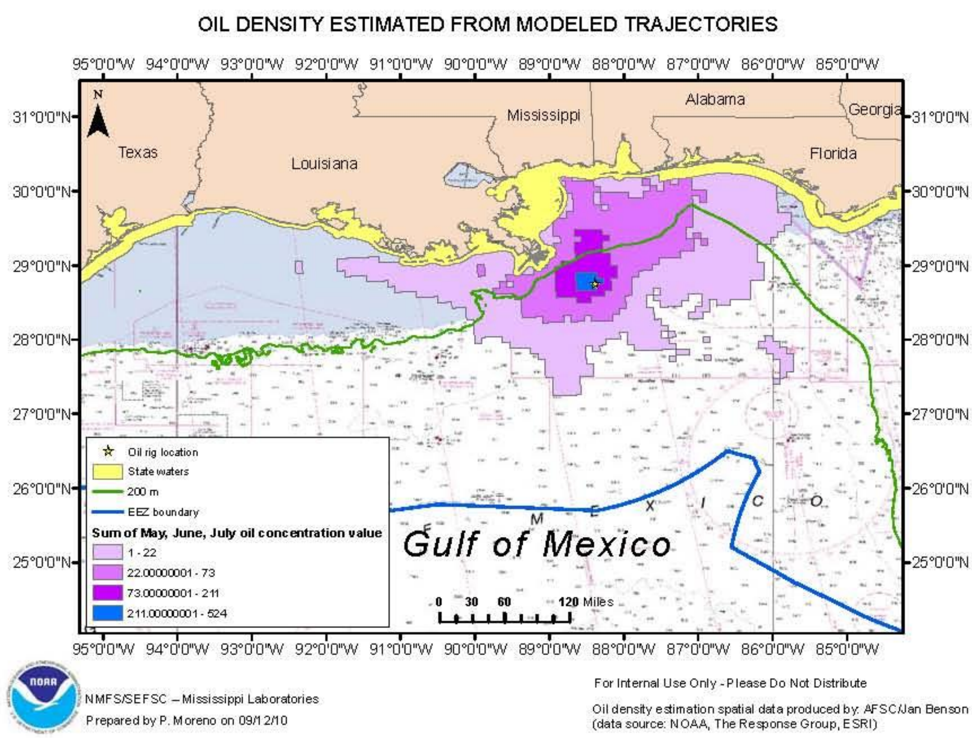
For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

Map of surface oil concentration estimation:

AFSC (Alaska Fisheries Science Center) produced a map summarizing oil density on a grid of 5-minute by 5-minute cells over the course of several months (see Figure below). This map represents the number of days that cells were oiled weighted by the severity of oil concentration (light = 1, medium = 5 and heavy = 10) and is based on the daily forecast trajectories (NOAA/NOS/OR&R).

There is a need to obtain an update of this map to include all the months covered by the trajectory forecasts with non-blank maps (May through early August).

In addition, it may be useful to develop a map that compiles information from all available sources (federal agencies, universities, industry, etc.), including observations and simulations of oil concentration and dispersion from the bottom to the surface.



NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

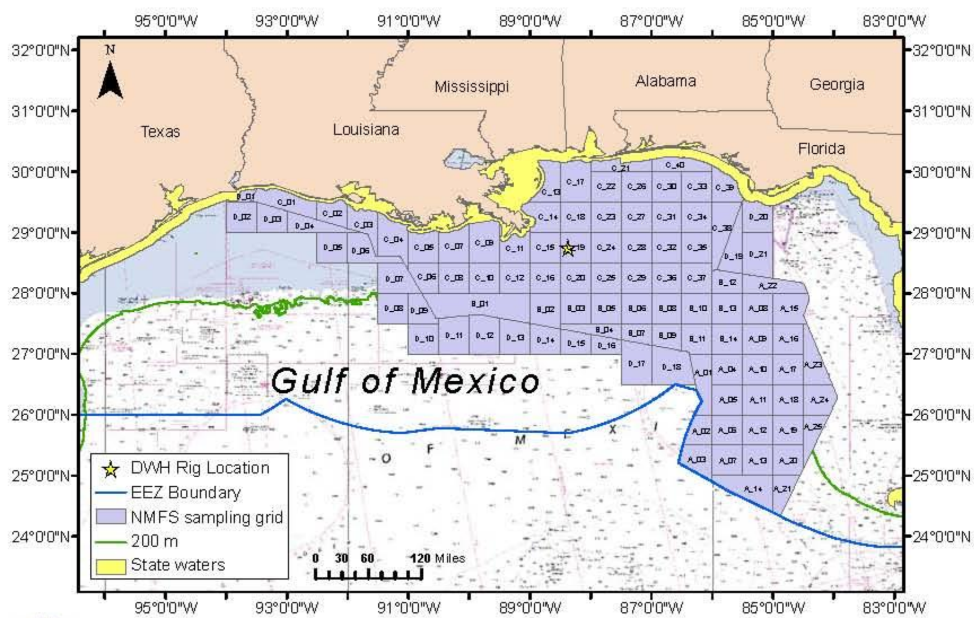
For SEAMAP/Deepwater Horizon Meeting, St. Petersburg, Florida, 21-24 September, 2010

Response Cruises:

Response cruises consisting of baseline, seafood surveillance and fisheries closure re-opening sampling have been conducted by the SEFSC, Mississippi Laboratories since the DWH incident occurred to collect baseline data on species distribution and specimens for seafood safety analysis. Sampled specimens are subject to chemical and sensory analysis conducted by the National Seafood Inspection Laboratory (NSIL). Baseline surveys were conducted in areas where oil is absent. The figure below shows the sampling grid that is currently the main focus of the response cruises.

While these surveys are not designed for population level assessment, the use of data collected during these surveys may be useful as a complement to other sources of oil contamination data used in determining the "impacted area".

National Marine Fisheries Services (NMFS) sampling grid
in response to the Deepwater Horizon, BP oil spill

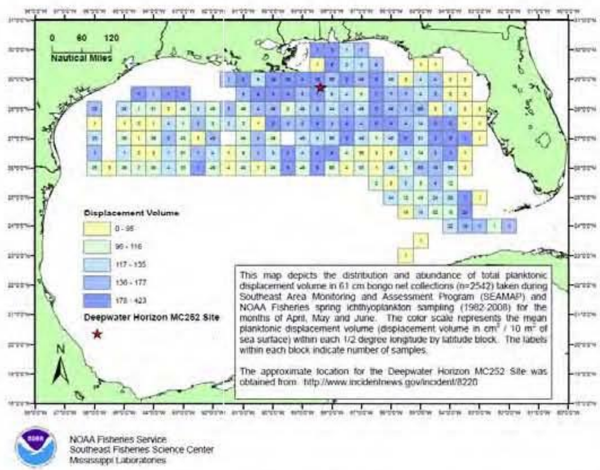


NMFS/SEFSC – Mississippi Laboratories
Prepared by P. Moreno on 09/10/10

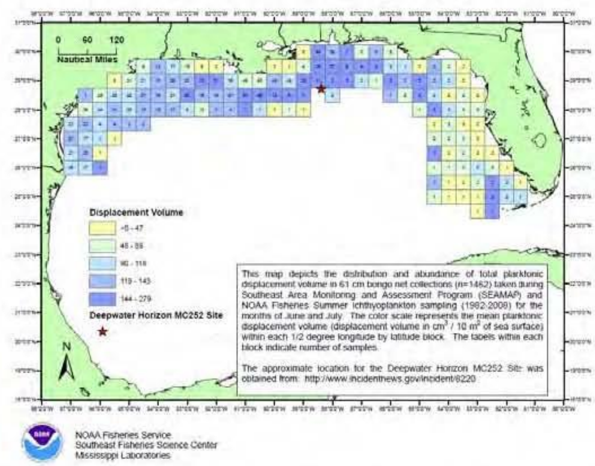
NOAA Fisheries Service
Southeast Fisheries Science Center
Mississippi Laboratories

Displacement Volume, Total Fish Eggs, and Total Fish Larvae Collected during spring and summer SEAMAP Plankton Surveys 1982-2008

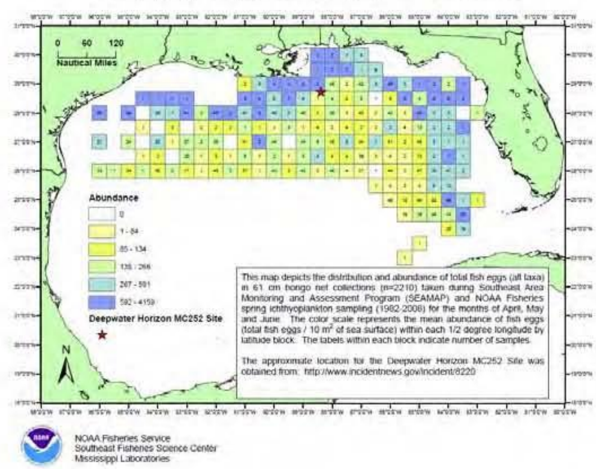
Distribution and abundance of total planktonic displacement volume in bongo net collections taken during Spring ichthyoplankton sampling from 1982 to 2008



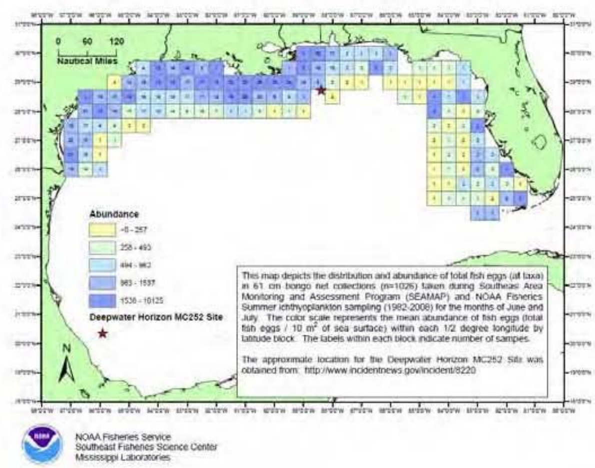
Distribution and abundance of total planktonic displacement volume in bongo net collections taken during Summer ichthyoplankton sampling from 1982 to 2008



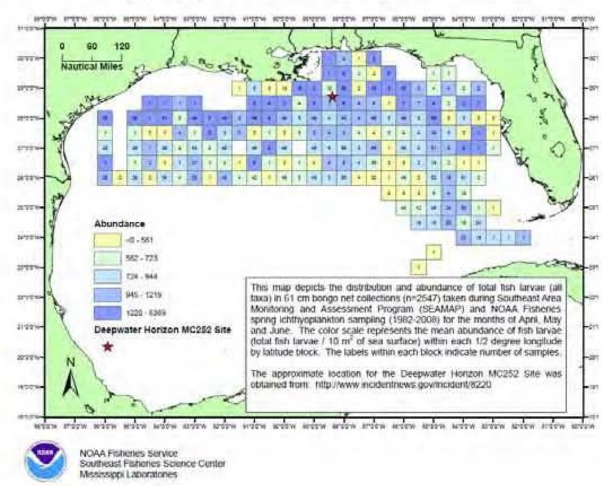
Distribution and abundance of total fish eggs (all taxa) in bongo net collections tak during Spring ichthyoplankton sampling from 1982 to 2008



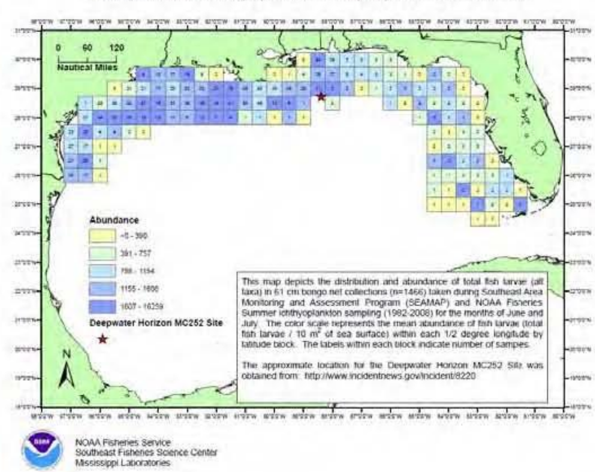
Distribution and abundance of total fish eggs (all taxa) in bongo net collections taken during Summer ichthyoplankton sampling from 1982 to 2008



Distribution and abundance of total fish larvae (all taxa) in bongo net collections during Spring ichthyoplankton sampling from 1982 to 2008



Distribution and abundance of total fish larvae (all taxa) in bongo net collections taken during Summer ichthyoplankton sampling from 1982 to 2008



SEAMAP Plankton Surveys Overview

Gear and methodology considered as standard for SEAMAP surveys are the 61 cm bongo net and 2 x 1 m neuston net.

- 61 cm (outside diameter) bongo frames fitted with 0.335 mm mesh netting fished in a double-oblique tow path from a maximum depth of 200 m or 2–5 m off the bottom at depths less than 200 m.
    - Catches of larvae are standardized to account for sampling effort and expressed as the number of larvae under 10 m^2 of sea surface.
- Single or double 2x1 m pipe frame neuston net fitted with 0.950 mm mesh netting is towed at the surface with the frame half-submerged for 10 min.
    - Catches of larvae are standardized to for sampling effort and expressed as the number of larvae per 10 minute tow.

61 cm bongo (left), single 2 x 1 neuston (center) and double 2 x 1 neuston (right).

Years Conducted and Depth Range:

- Spring Plankton Survey
    - Conducted annually since 1982 from April to early June.
    - Covers open Gulf of Mexico waters from the U.S. continental shelf to the exclusive economic zone.
    - Dedicated plankton survey.

- Summer Ground fish Survey
  - Conducted annually since 1982 during June and July
  - Covers U.S. continental shelf from Brownsville, TX to Mobile Bay, Alabama (~88 Degrees West Longitude). Early in the time series sampling was conducted on the west Florida shelf.
  - Plankton sampling conducted along with trawling operations.

- Fall Plankton Survey
  - Conducted annually since 1986 from late August to mid October with most sampling occurring during the month of September.
  - Covers the U.S. continental shelf from Brownsville, TX to Key West Florida.
  - Dedicated plankton survey.

- Fall Ground fish Survey
  - Annually since 1986 during June and July
  - Covers U.S. continental shelf from Brownsville, TX to Mobile Bay, Alabama (~88 Degrees West Longitude).
  - Plankton sampling conducted along with trawling operations.

- Winter Plankton Survey
  - Four surveys in 1983, 1984, 1993 and 1996 in open Gulf of Mexico waters.
  - More recently, surveys in 2007, 2008 and 2009 extending from mid shelf into the U.S. open Gulf of Mexico.
  - Variable coverage throughout the Gulf among years.
  - Dedicated plankton survey.

Survey Design:

- The overall SEAMAP sampling area covers the entire northern GOM from the 10 m isobath out to the U.S. EEZ, and comprises approximately 300 designated sampling sites, i.e. 'SEAMAP' stations.

- Most stations are located at 30-nautical mile or 0.5^{o} (~56 km) intervals in a fixed, systematic, 2-dimensional latitude-longitude grid of transects across the GOM. Some SEAMAP stations are located at < 56 km intervals especially along the continental shelf edge, while others have been moved to avoid obstructions, navigational hazards or shallow water.

- The majority of SEAMAP plankton samples are taken during dedicated plankton surveys and shrimp/bottomfish (trawl) surveys.

Survey Design Changes:

- Starting in 1990 and continuing through 2001, marine mammal observations were an integral component of the Spring SEAMAP Plankton survey. Two changes were made to the survey design to accommodate the marine mammals work.

    - The survey area was expanded to the west from 94 to 96 ° W longitude and station transects were sampled entirely along a north/south heading and not the original 'zigzag' pattern.

    - The expanded survey area (i.e. to 96 ° W longitude) remains as the spring survey area but the original 'survey track' or zigzag pattern has been resumed.

- Beginning in 1999 and continuing to the present 11 additional SEAMAP stations located off the continental shelf were added to the Fall Plankton survey.

Plankton Sample Processing and Identification

Essential elements of SEAMAP plankton survey activities include sample processing (sorting and identification), specimen archival and re-examination of selected taxa.

- SEAMAP plankton samples are sorted for fish eggs, fish larvae and, since 2004, invertebrate zooplankton at the Sea Fisheries Institute, Plankton Sorting and Identification Center in Gdynia and Szczecin, Poland under a Joint Studies Agreement between the NMFS and the Sea Fisheries Institute.

- Vials of fish eggs, larvae (most identified to the family only), plankton displacement volumes, total egg counts; and counts and body length measurements of identified specimens are sent to the SEAMAP Archive at the Fish and Wildlife Research Institute, Florida Fish and Wildlife Commission, St. Petersburg, FL.

- Identified invertebrate zooplankton are sent to the SEAMAP Invertebrate Archiving Center (SIPAC) at Gulf Coast Research Lab in Ocean Springs, MS.

- Examination and re-identification of the fish larvae of select taxa by SEFSC ichthyoplankton specialists are routinely undertaken in order to assure accurate and consistent identifications over the time series.

- Larvae of tuna, king & Spanish mackerels, red snapper, vermilion snapper, and gray triggerfish are re-examined prior to inclusion of larval abundance estimates used in stock assessments.

Dominant taxa, ranked by frequency of occurrence, collected in bongo and neuston tows, during SEAMAP resource surveys conducted in the Gulf of Mexico by NMFS Pascagoula Lab.

Spring Plankton Survey

Taxon	Bongo	Taxon	Neuston
MYCTOPHIDAE	79.35	EXOCOETIDAE	76.19
GONOSTOMATIDAE	75.53	MULLIDAE	43.89
DIAPHUS	75.40	CARANX	37.10
BREGMACEROS	74.26	CUBICEPS	29.47
CYCLOTHONE	73.38	THUNNUS	26.77
HYGOPHUM	69.13	UNIDENTIFIED FISH	26.34
MYCTOPHUM	66.78	CORYPHAENA HIPPURUS	24.36
UNIDENTIFIED FISH	64.80	MYCTOPHIDAE	23.76
PARALEPIDIDAE	63.29	MYCTOPHUM	22.56
BENTHOSEMA	57.23	SERIOLA	19.81

Summer Ground fish Survey

Taxon	Bongo	Taxon	Neuston
ENGRAULIDAE	89.67	EXOCOETIDAE	62.66
GOBIIDAE	77.67	ENGRAULIDAE	59.61
SYMPHURUS	70.95	CHLOROSCOMBRUS CHRYSURUS	43.00
OPHIDIIDAE	60.12	HARENGULA JAGUANA	40.31
SYNODONTIDAE	55.42	GERREIDAE	37.61
BREGMACEROS	52.39	BLENNIIDAE	32.76
CHLOROSCOMBRUS CHRYSURUS	51.05	CARANX CRYSOS	29.89
UNIDENTIFIED FISH	50.97	CARANX	26.75
BOTHIDAE	44.58	MULLIDAE	25.85
SYACIUM	39.63	SPHOEROIDES	25.49

Fall Plankton Survey

Taxon	Bongo	Taxon	Neuston
GOBIIDAE	88.37	EXOCOETIDAE	56.77
UNIDENTIFIED FISH	68.19	ENGRAULIDAE	50.53
ENGRAULIDAE	65.80	CHLOROSCOMBRUS CHRYSURUS	44.88
OPHIDIIDAE	65.49	GERREIDAE	37.77
SYMPHURUS	64.24	GOBIIDAE	36.71
SYNODONTIDAE	61.69	DECAPTERUS PUNCTATUS	30.51
BREGMACEROS	56.33	SYMPHURUS	29.84
BOTHIDAE	46.81	UNIDENTIFIED FISH	24.46
CHLOROSCOMBRUS CHRYSURUS	45.44	OPISTHONEMA OGLINUM	23.75
SCORPAENIDAE	44.58	HARENGULA JAGUANA	23.71

Fall Ground fish Survey

Taxon	Bongo	Taxon	Neuston
GOBIIDAE	84.51	ENGRAULIDAE	48.45
OPHIDIIDAE	74.67	MICROPOGONIAS UNDULATUS	47.67
BREGMACEROS	72.41	EXOCOETIDAE	41.13
MICROPOGONIAS UNDULATUS	70.15	SYMPHURUS	39.14
SYMPHURUS	61.44	GOBIIDAE	38.91
ENGRAULIDAE	53.23	OPHIDIIDAE	35.03
UNIDENTIFIED FISH	50.36	UNIDENTIFIED FISH	34.04
SYNODONTIDAE	45.64	BREGMACEROS	32.26
BOTHIDAE	43.28	BREVOORTIA	32.04
PEPRILUS BURTI	37.85	POMOTOMUS SALTATRIX	31.60

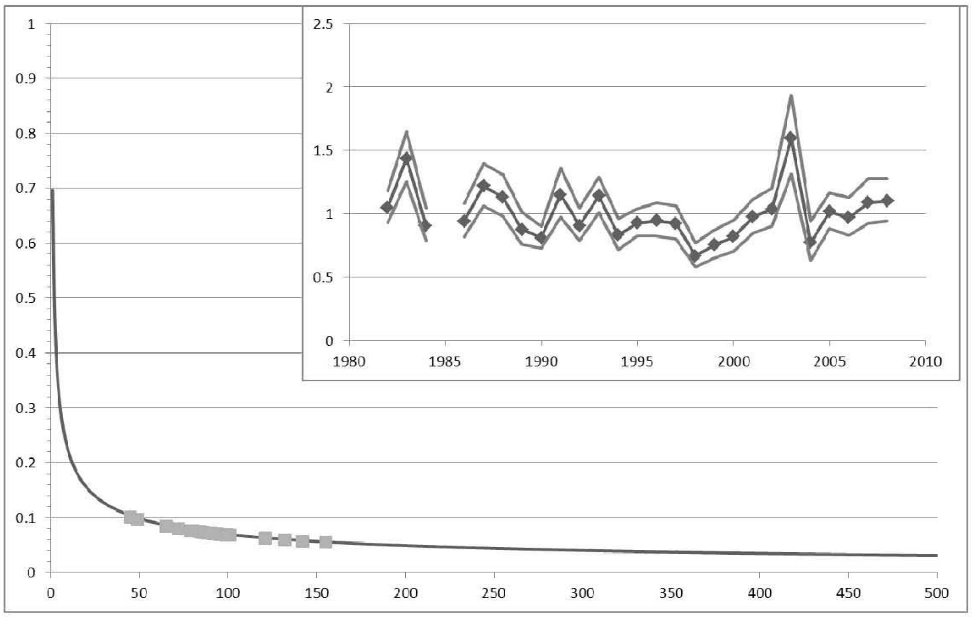
Winter Plankton Survey

Taxon	Bongo	Taxon	Neuston
BREGMACEROS	90.22	UNIDENTIFIED FISH	56.11
GONOSTOMATIDAE	83.70	EXOCOETIDAE	54.44
DIAPHUS	82.61	BREGMACEROS	47.78
UNIDENTIFIED FISH	80.98	MYCTOPHIDAE	47.22
CYCLOTHONE	76.63	HYGOPHUM	46.11
HYGOPHUM	75.54	CYCLOTHONE	45.00
BENTHOSEMA	75.00	GOBIIDAE	40.56
GOBIIDAE	75.00	MYCTOPHUM	35.56
MYCTOPHIDAE	72.28	DIAPHUS	34.44
STERNOPTYCHIDAE	65.76	LAMPANYCTUS	33.33

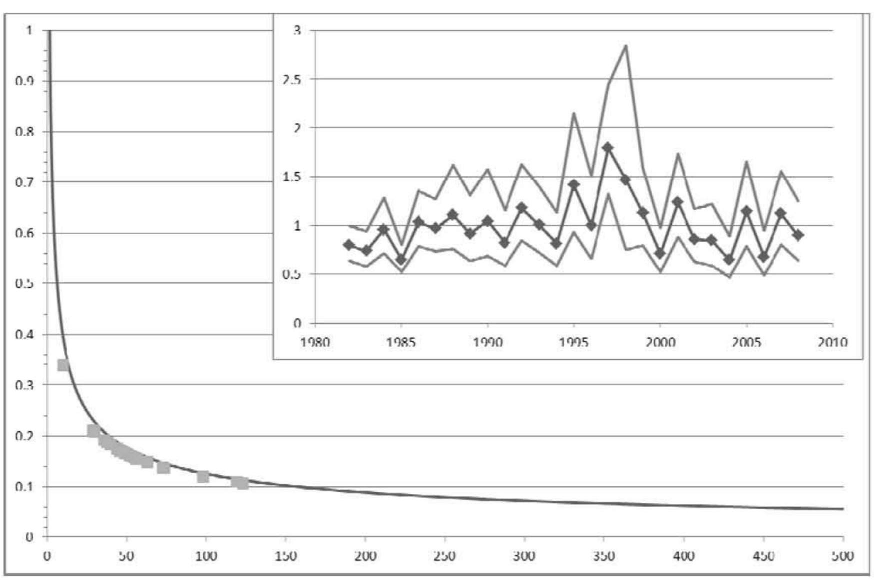
<u>CV and Index Plots for Fish Eggs, Displacement Volume and Selected Important Taxa from the SEAMAP Ichthyoplankton Surveys Conducted in the Gulf of Mexico</u>

For each plot, the smaller graph is of annual relative abundance indices (with 95% confidence intervals) with relative abundance on the vertical axis and survey year on the horizontal axis. The larger graph consists of two plots with CV (coefficient of variation of the mean index value) on the vertical axis and sample size on the horizontal axis. The continuous line represents a theoretical CV by sample size, which is based on the points therein. The points represent actual CV values and survey sample sizes.

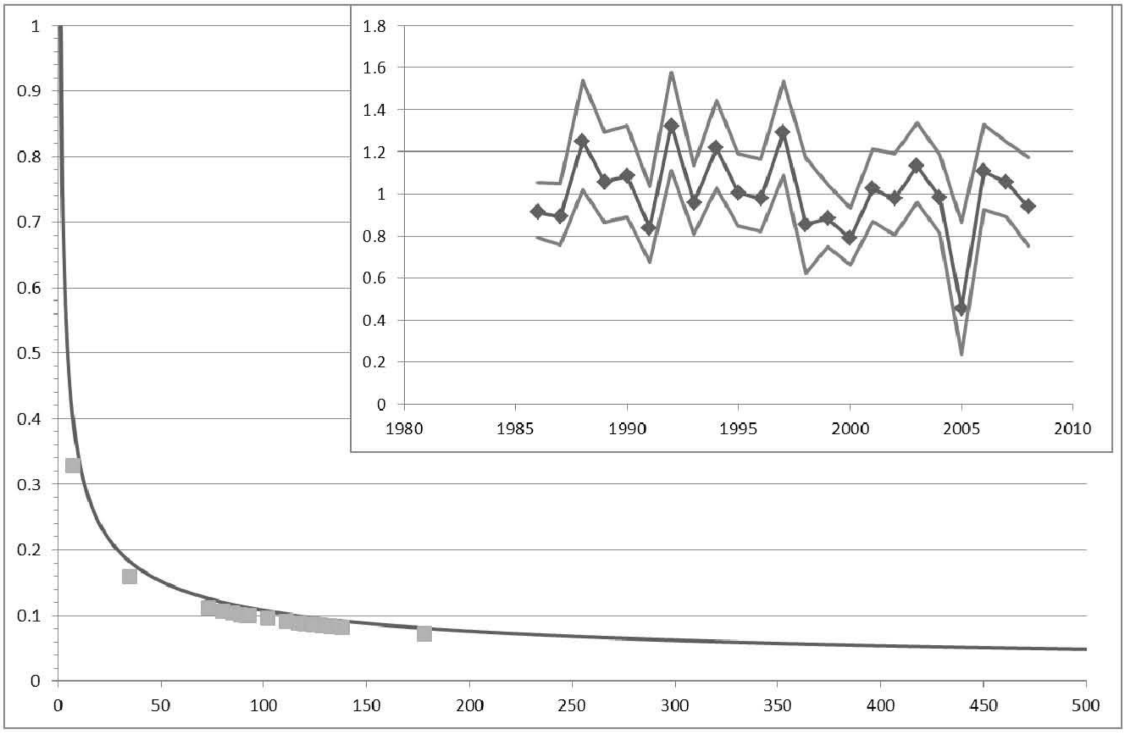
Displacement Volume – Spring Survey



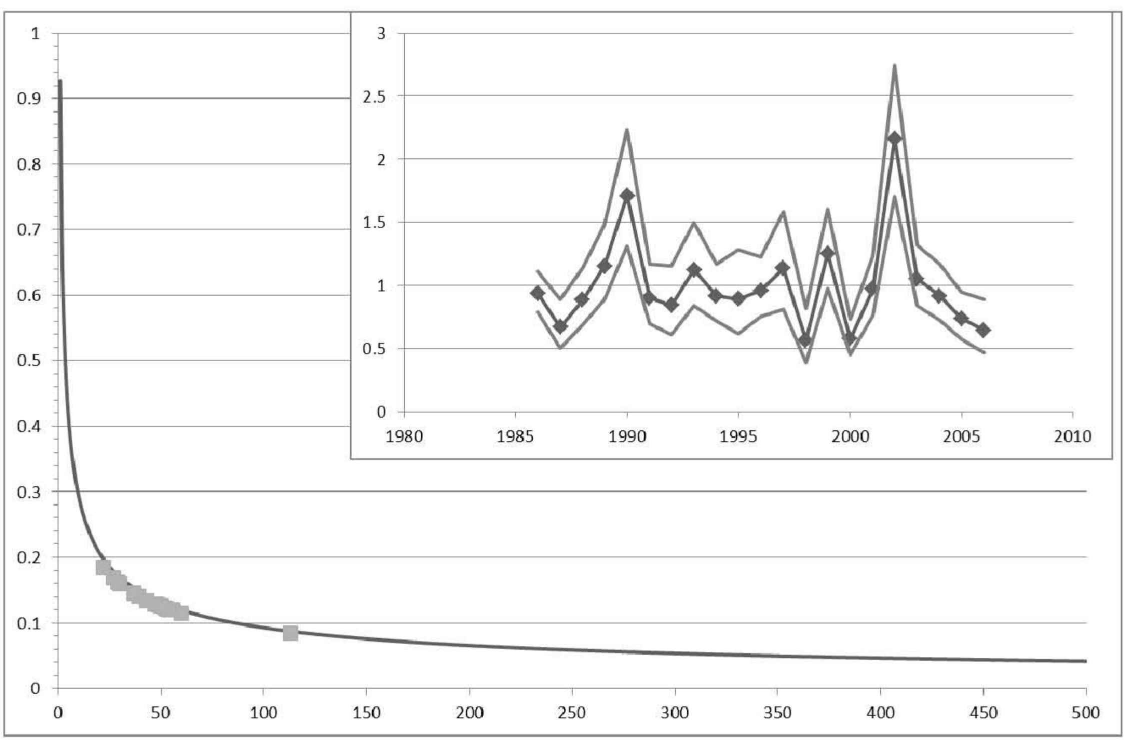
Displacement Volume – Summer Ground fish Survey



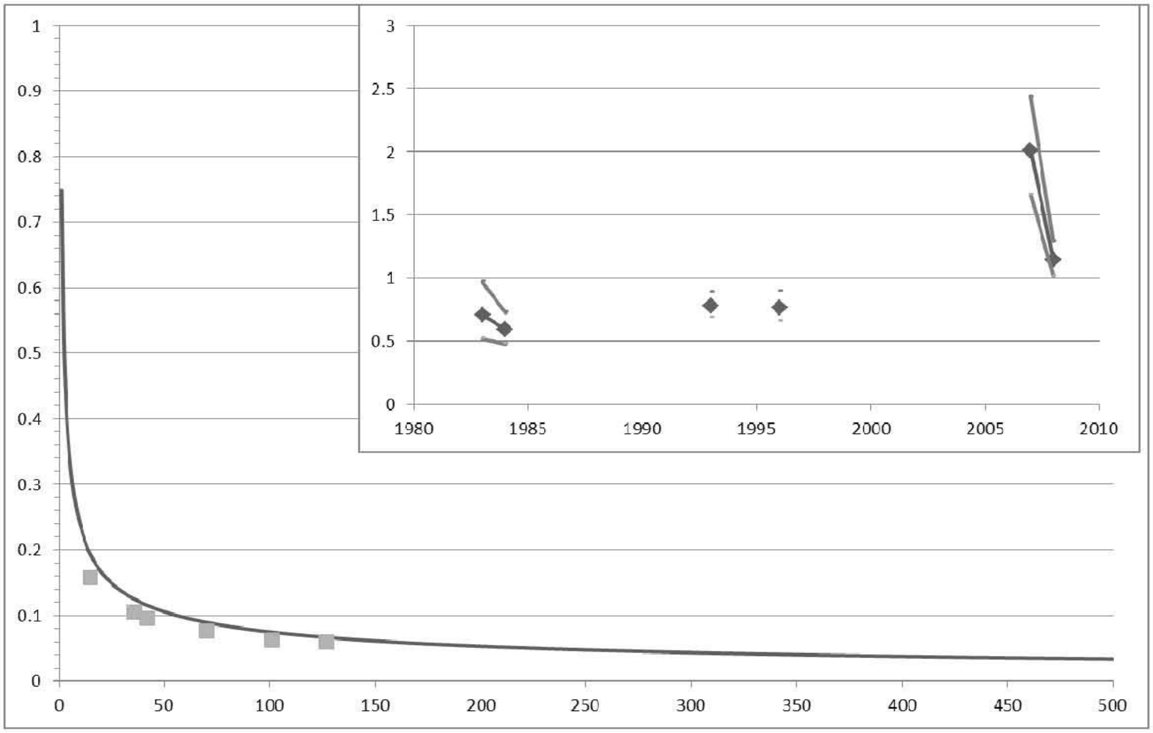
Displacement Volume – Fall Plankton Survey



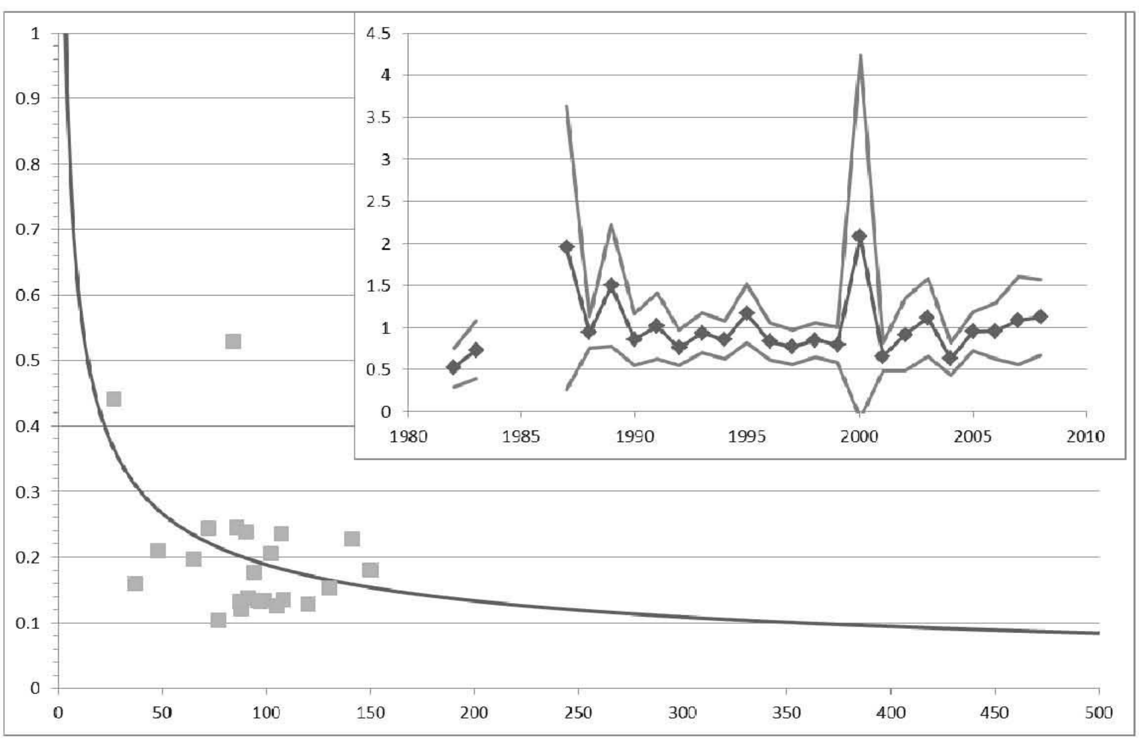
Displacement Volume – Fall Ground fish Survey



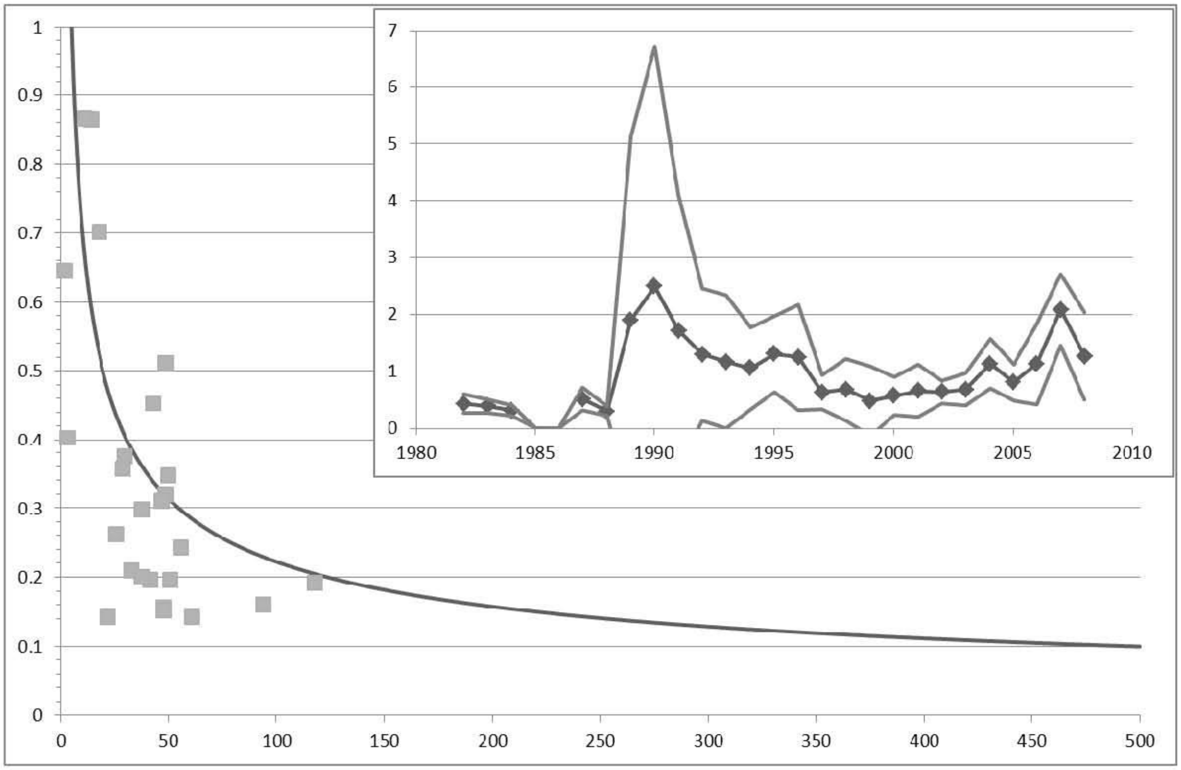
Displacement Volume – Winter Survey



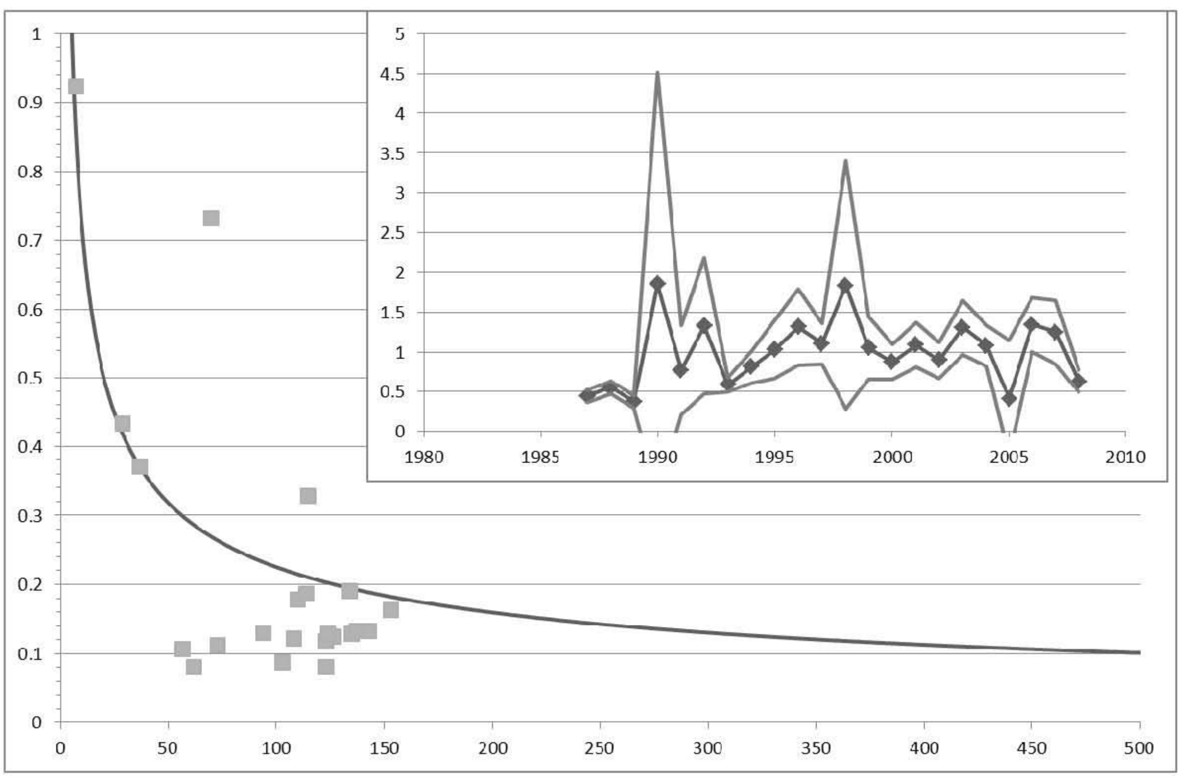
Total Fish Eggs – Spring Survey



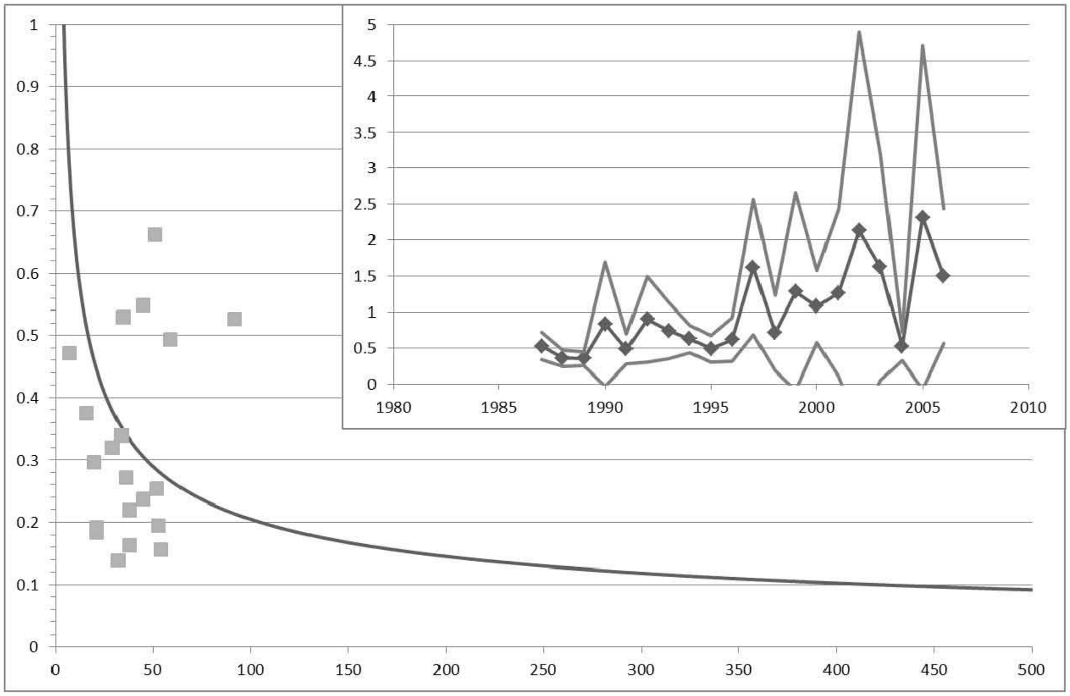
Total Fish Eggs – Summer Ground fish Survey



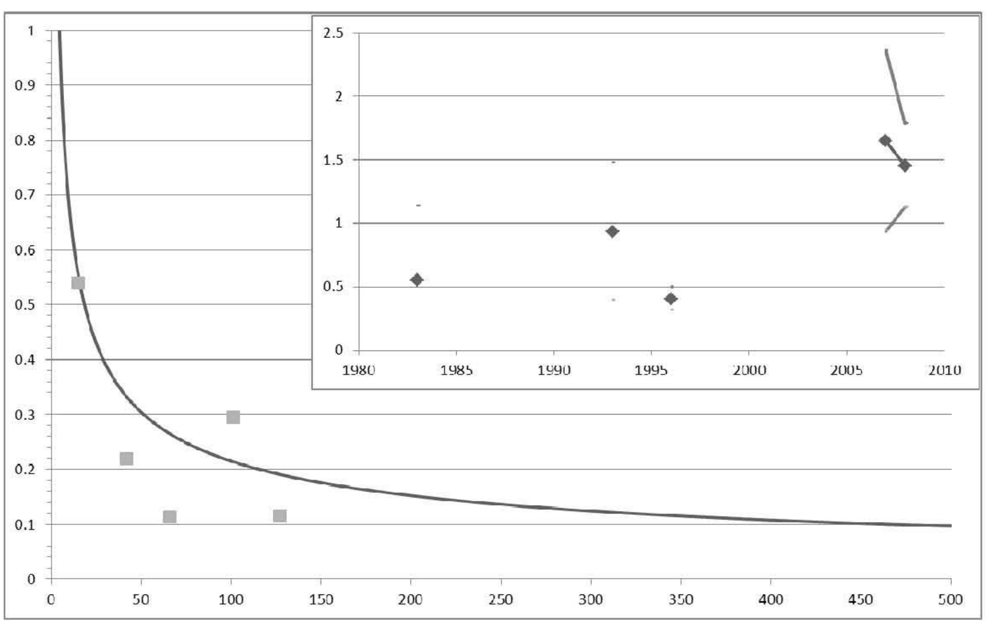
Total Fish Eggs – Fall Plankton Survey



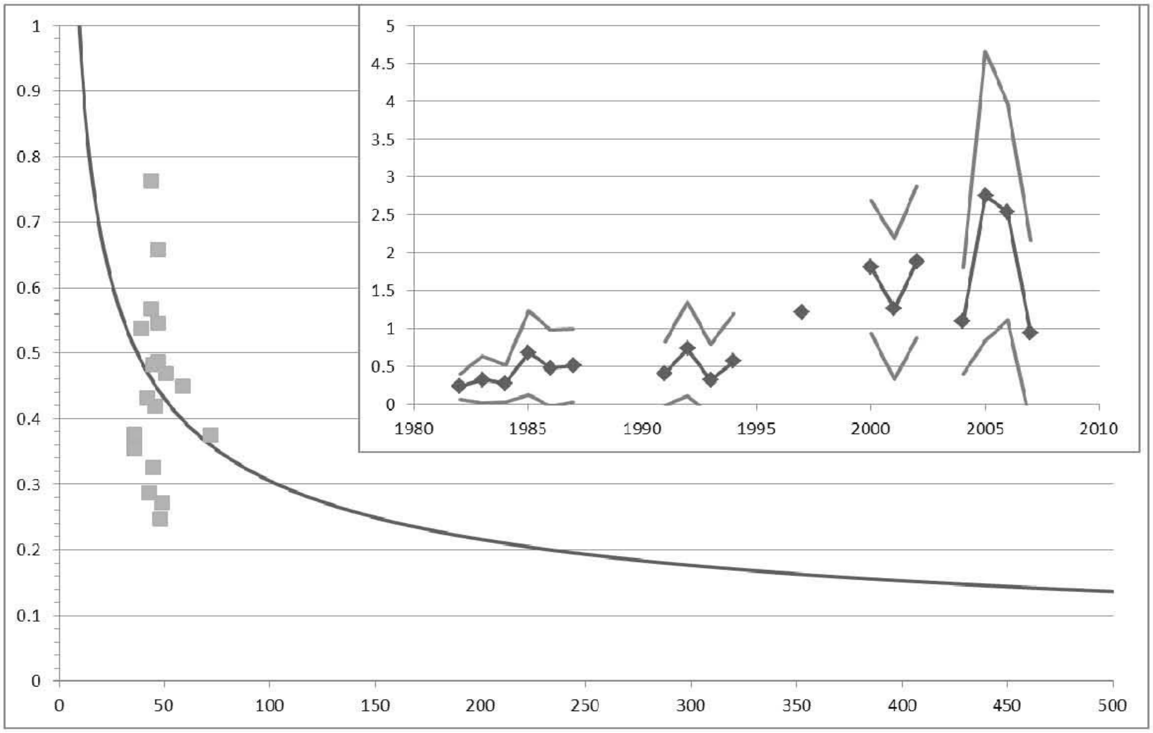
Total Fish Eggs – Fall Ground fish Survey



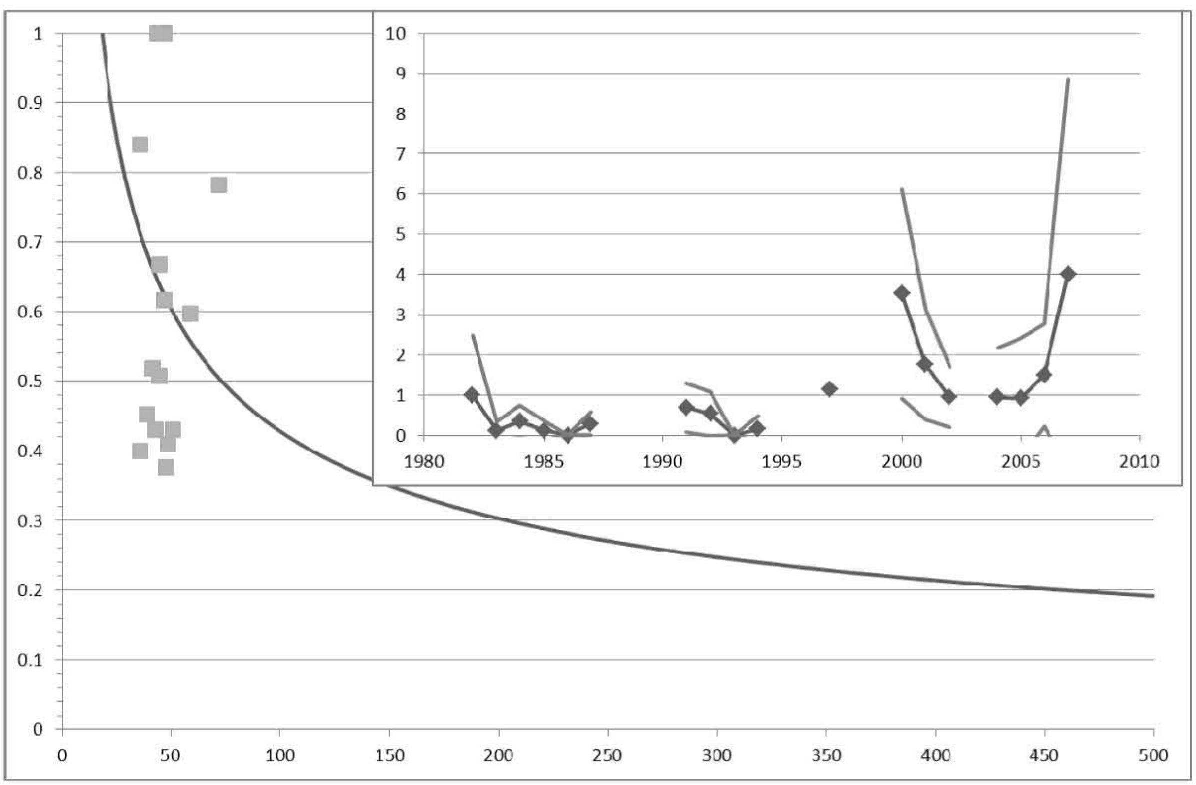
Total Fish Eggs – Winter Survey



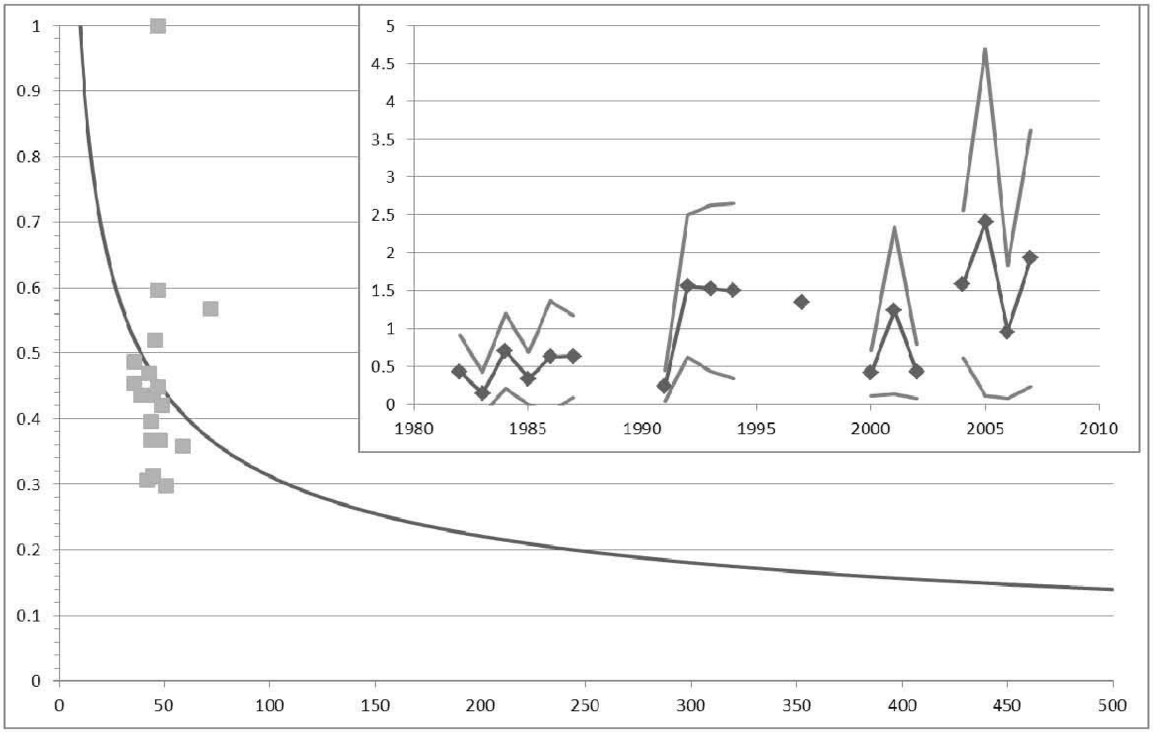
Red Snapper – Summer Ground fish Survey



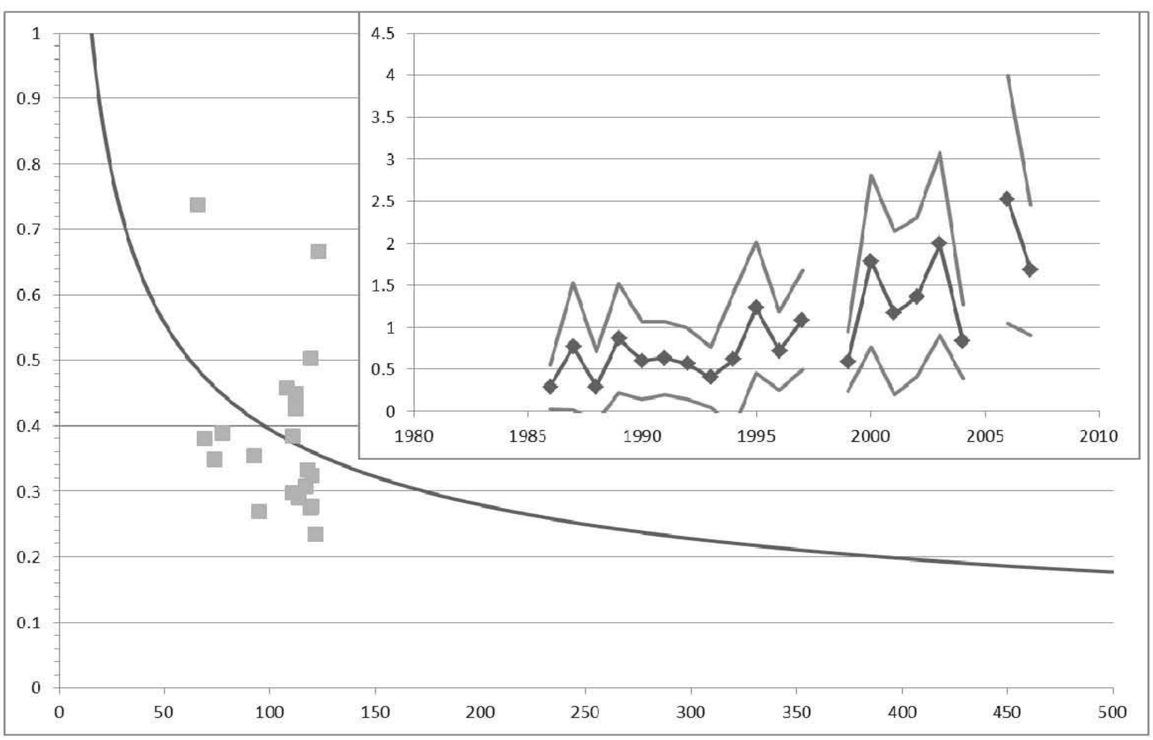
Vermilion Snapper – Summer Ground fish Survey



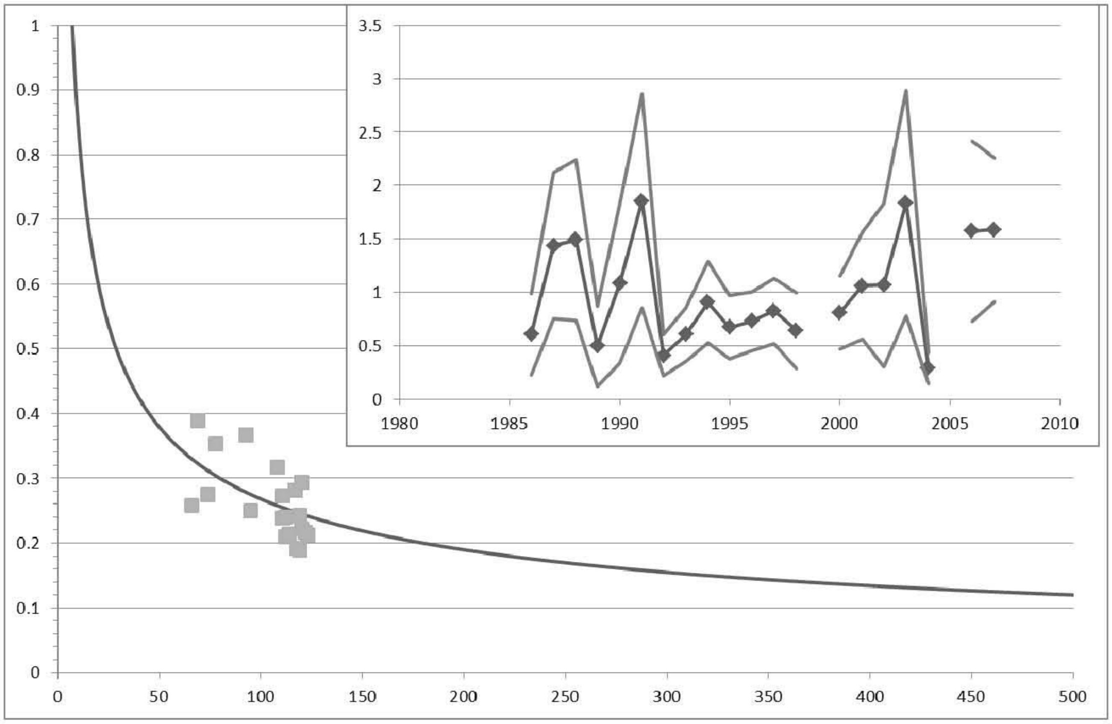
King Mackerel – Summer Ground fish Survey



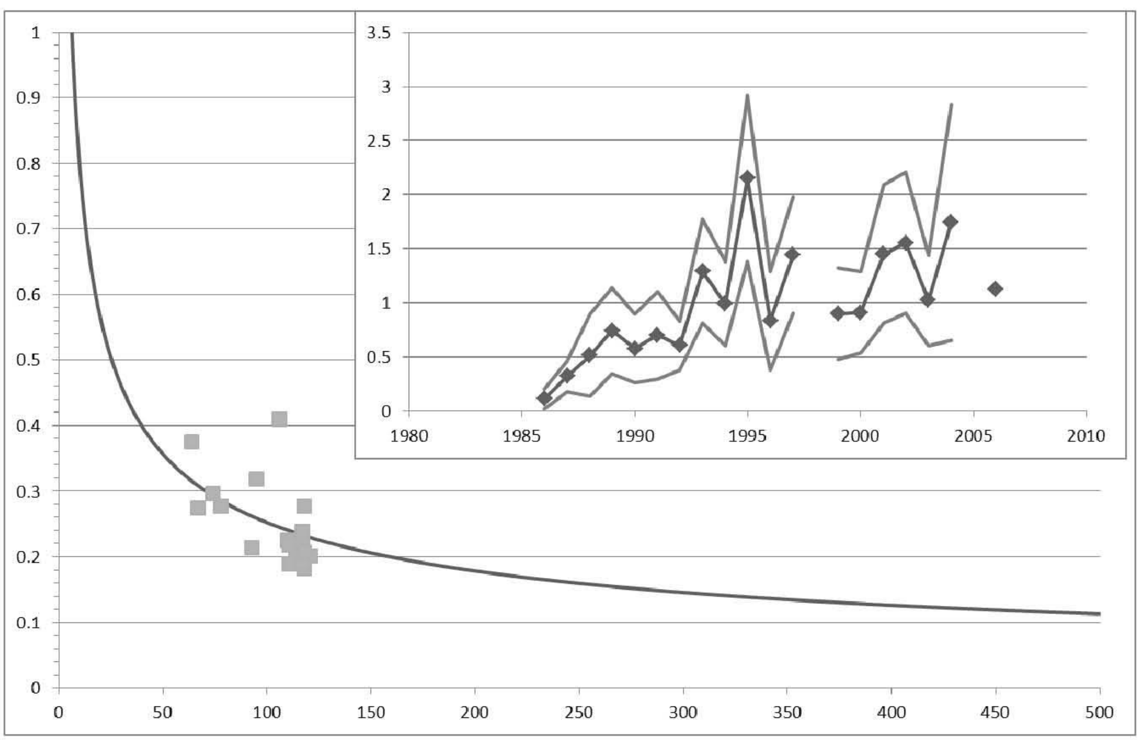
Red Snapper – Fall Plankton Survey



Vermilion Snapper – Fall Plankton Survey

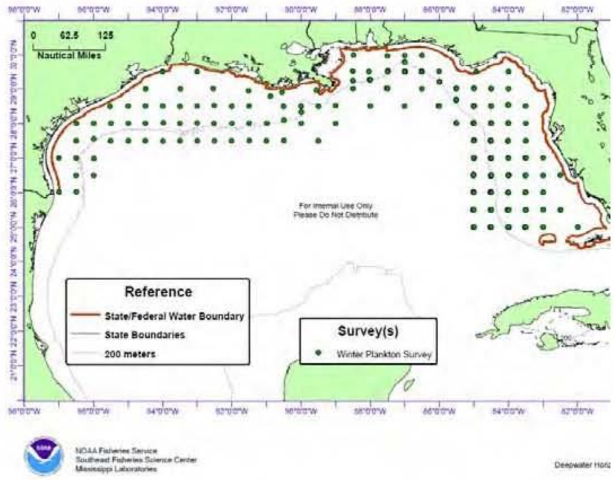


King Mackerel – Fall Plankton Survey

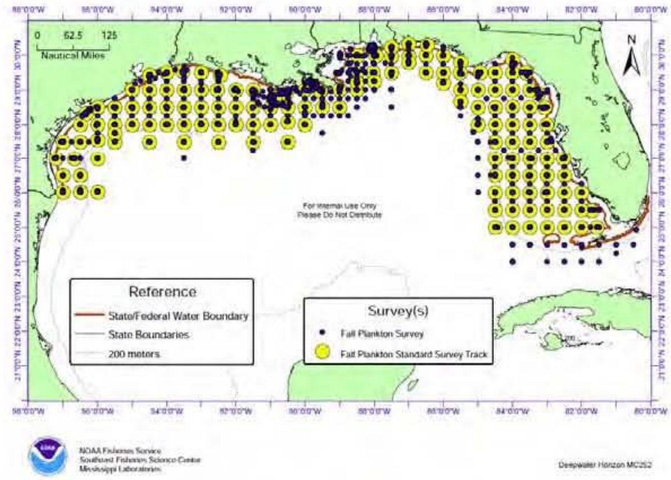


SEAMAP PLANKTON SAMPLING EFFORT
During dedicated plankton and trawl surveys

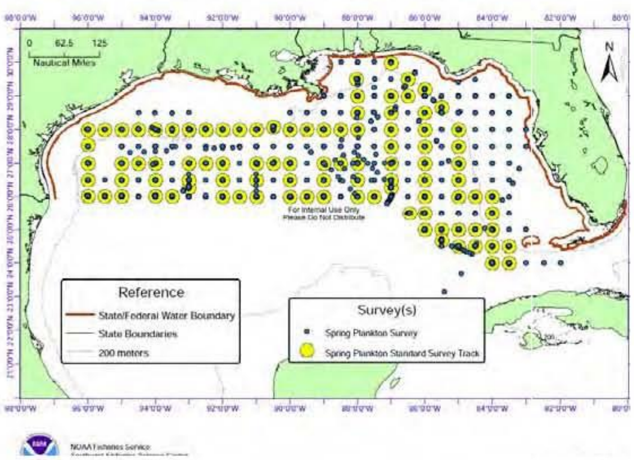
Winter Plankton Survey Effort 2007 and 2008



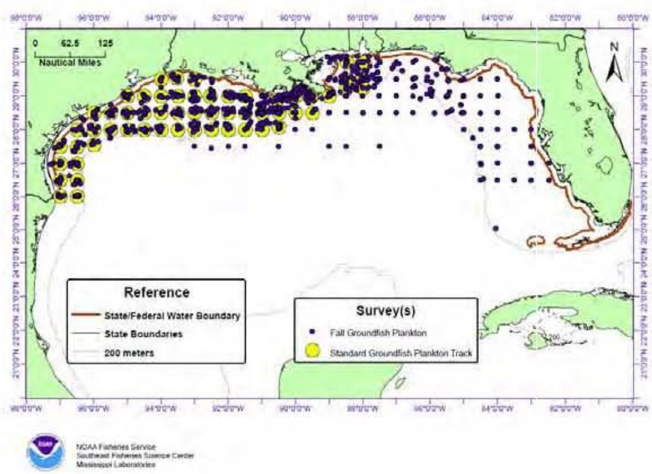
Fall Plankton Survey Effort 1986-2008



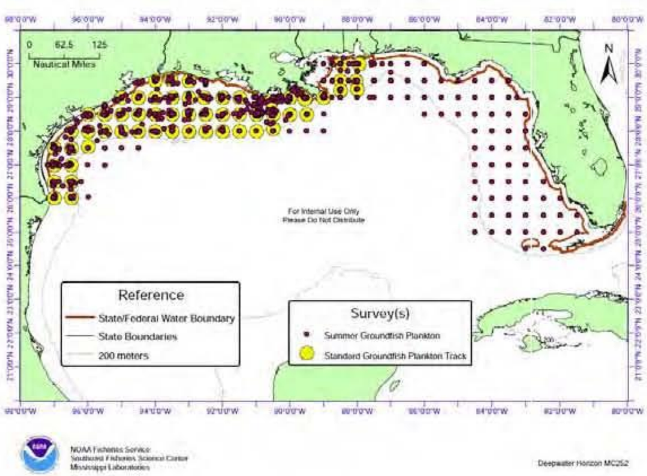
Spring Plankton Survey Effort 1982-2008



Fall Groundfish Plankton Effort 1982-2008

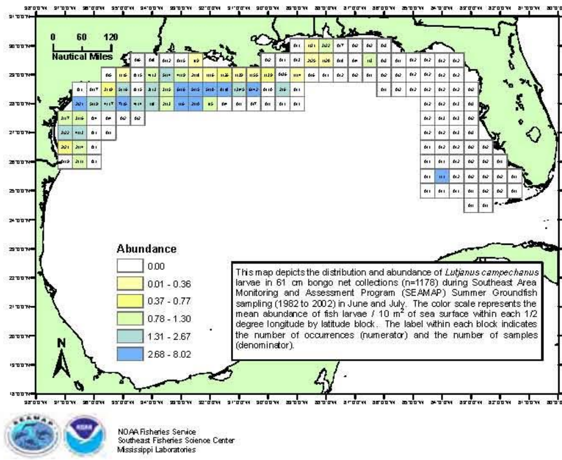


Summer Groundfish Plankton Effort 1982-2008

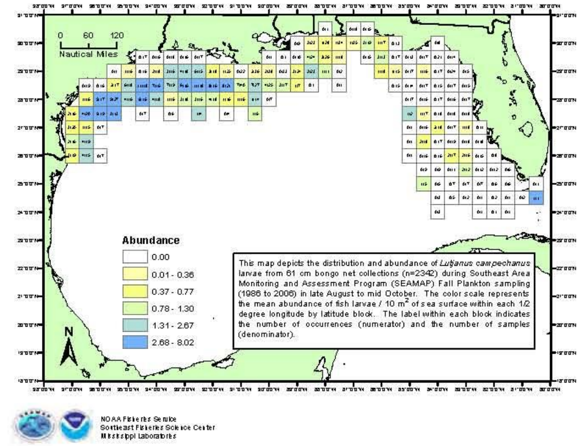


Distribution and abundance of select taxa from SEAMAP surveys

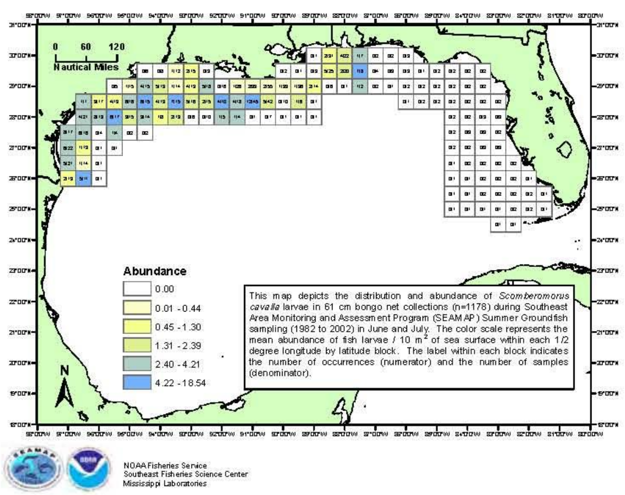
Distribution and abundance of *Lutjanus campechanus* (red snapper) larvae in bongo net collections during SEAMAP Summer Groundfish sampling (1982 to 2002) in June and July.



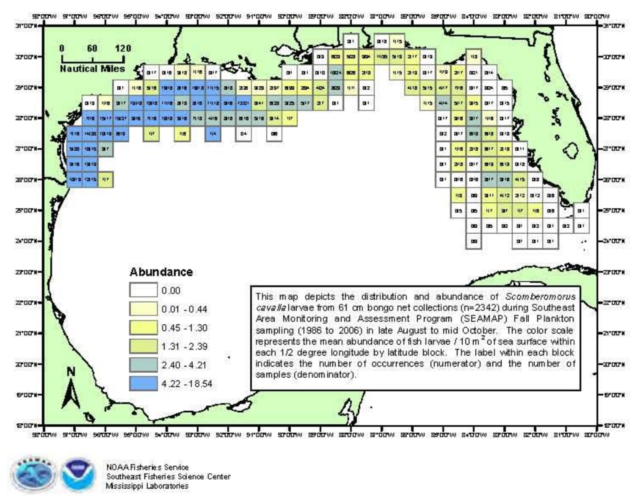
Distribution and abundance of *Lutjanus campechanus* (red snapper) larvae in bongo net collections during SEAMAP Fall Plankton sampling (1986 to 2006) in late August to mid October



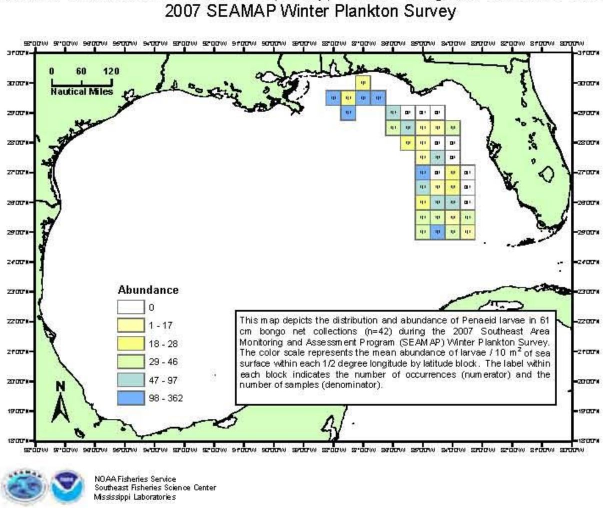
Distribution and abundance of *Scomberomorus cavalla* (king mackerel) larvae in bongo net collections during SEAMAP Summer Groundfish sampling (1982 to 2002) in June and July.



Distribution and abundance of *Scomberomorus cavalla* (king mackerel) larvae in bongo net collections during SEAMAP Fall Plankton sampling (1986 to 2006) in late August to mid October



Distribution and abundance of Penaeid (shrimp) larvae in bongo net collections during the 2007 SEAMAP Winter Plankton Survey



Distribution and abundance of Penaeid (shrimp) larvae in bongo net collections during the 2003 SEAMAP Fall Plankton Survey